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Comparative changes in *Eucalyptus pauciflora* (Myrtaceae) stand structure after bushfires in Victoria

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***Abstract*:** The recent frequency and extent of landscape-scale fires in subalpine areas of Victoria have led to almost all *Eucalyptus pauciflora* (snow gum) forests and woodlands being burnt, to the extent that old growth stands are now rare. A comparison of *Eucalyptus pauciflora* stand structure at three mountains with comparable geology, altitude, topography and grazing history but with different fire histories revealed three regeneration syndromes: (i) long-unburnt stands consisting of few-stemmed trees at Mt Baw Baw and recently-burnt stands at Lake Mountain, both characterised by a single establishment phase in response to fire disturbance; (ii) long-unburnt stands consisting of few-stemmed trees at Mt Buffalo, characterised by continuous regeneration and ongoing seedling recruitment independent of major disturbances, and (iii) multi-burnt stands with high tree density and thin stems at Mt Buffalo, with multiple stem establishment phases.

At some sites with very high fire frequency and/or short inter-fire intervals, multi-or thin-stemmed architecture may have become entrenched. Post-fire seedling recruitment is high but seedlings are likely to be outcompeted and remain in a suppressed state. Snow gum is a tenacious niche persistor with capacity to resprout after multiple fires but the current outlook is one of a radical demographic shift in population structure in subalpine landscapes. It is crucial that remaining long-unburnt *Eucalyptus pauciflora* stands are protected from fire as far as is practicable to allow stand development and to preserve the unique quality and function of mature snow gum woodlands.

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Introduction

Recent high fire frequencies in mountainous terrain in south-eastern Australia have provided many opportunities to improve our understanding of post-fire vegetation recovery. However, opportunities to gather information on unburnt or rarely burnt subalpine vegetation are now exceedingly rare. High fire frequency is expected to continue into the future (Parry *et al.* 2007), including in areas with a history of infrequent fire. The response of species to repeated perturbations poses a number of challenges for predicting thresholds beyond which recovery to a previous state may not occur (Westman 1986).

Eucalyptus pauciflora Sieber ex Spreng. occurs in south-eastern Queensland, eastern New South Wales (NSW), the Australian Capital Territory (ACT), south-eastern South Australia, Tasmania and Victoria (Williams & Ladiges 1985). Snow gum forests occupy a range of altitudes between sea level and 2000 m but are most often associated with alpine and subalpine treelines on shallow rocky soils (Boland *et al.* 1984; Williams & Ladiges 1985; Brookhouse *et al.* 2008). Vegetation dominated by snow gum in Victoria is usually confined to mountains with elevations generally above about 1100 m ASL. Since 2003, all except one of these mountains (Mt Baw Baw) have been burnt in bushfires. In the most recent landscape-scale fire in 2009, some of the

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last remaining long-unburnt subalpine vegetation at Lake Mountain was burnt at extremely high severity. This was the first fire to have reached the plateau since 1939. Mires, shrublands and extensive tracts of snow gum forest were all affected.

Snow gum is considered a resilient, long-lived tree, with stems likely to persist for at least 325 years (Barker 1988). Lignotuber ages are unknown but are likely to be much older since these are generally protected from fire (Rumpff 2008) . Resprouting following fire-induced canopy removal is initially prolific but over time, stem thinning occurs as the upper branches extend and shade lower branches (Barker 1988; Noble 2001). Climate-related stress, such as drought or frost may induce low level resprouting at other times (Bell & Williams 1997). Adult mortality resulting from the death of the lignotuber after a single fire is rare but has been observed after repeated fires (Banks 1986; Noble 2001). Snow gums can also regenerate from seed following fire and after about six months of age, seedlings have well-developed lignotubers (Leigh & Holgate 1979; Carr *et al.* 1984; Noble 1984; Barker 1989), although grazing by domestic livestock and feral herbivores has reduced the rate of post-fire seedling survival at many locations (Wimbush & Forrester 1988; Wearne & Morgan 2001; Pickering & Barry 2005). Nevertheless, snow gum characteristically has dual reproductive mechanisms and therefore the 'best of both worlds' (Bond & Midgley 2001).

Since European occupation, widespread stock grazing, increased deliberate burning and extensive bushfires have affected much of the alpine and subalpine landscapes of south-eastern Australia (Rumpff 2008). This is thought to have led to the conversion of mature snow gum woodlands to dense stands of multi-stemmed mallees at some localities (Costin 1967; Good 1982 in Pickering & Barry 2005; Barker 1989; Pickering & Barry 2005; Rumpff 2008). At many of these, there has been insufficient time between fires (<100 years) to allow self-thinning of regrowth stems and a return to more open stand structure (Rumpff 2008).

The majority of studies which have examined the relationship between fire frequency and stem structure have focussed on alpine areas above 1700 m ASL (e.g. Banks 1986; Barker 1988; Barker 1989; Rumpff 2008) but there is comparatively little work at sites at lower elevations (e.g. Ashton & Hargreaves 1983). At these climatically more favourable locations, trees would be expected to tend toward a single-stemmed habit (Lacey & Johnston 1990). However, multi-stemmed trees also dominate sites which are known to have been burnt in one or more fires, or occupy a range of topographies with varying environmental and climatic limitations (e.g. soil depth, aspect and rockiness), which also promote multi-stemmed architecture (Lacey & Johnston 1990; Rumpff 2008).

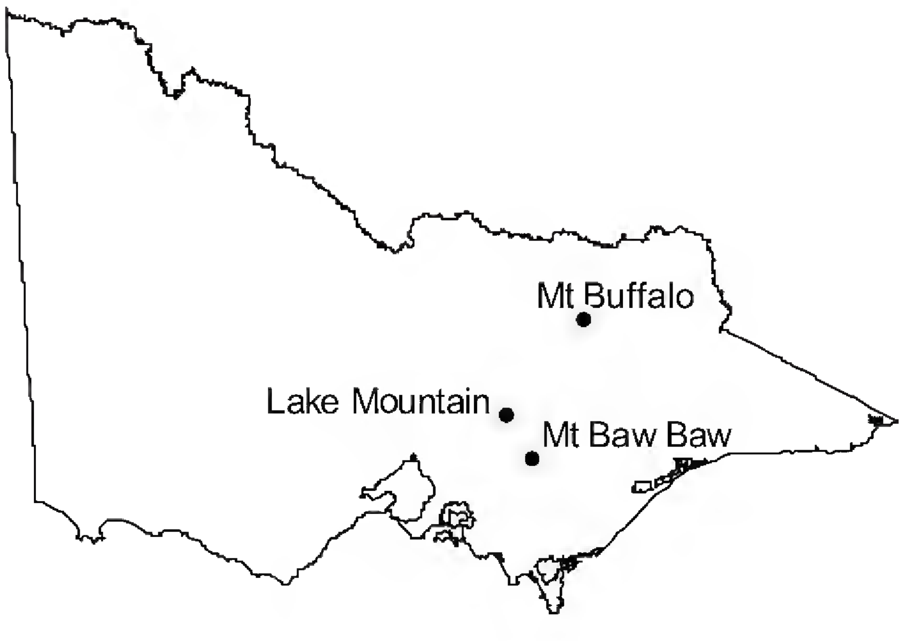

Fig. 1. Locations of Lake Mountain, Mt Baw Baw and Mt Buffalo.

The regime of widespread, high-intensity fire which has prevailed in south-eastern Victoria since 2003 has caused considerable changes to the structure of snow gum forest. As yet, the exact nature of these changes is uncertain. Most trees have vigorously resprouted and in this respect, snow gum is a "niche persistor" and is typical of slow growing plants in low productivity environments able to efficiently re-occupy a site after disturbance (Bellingham & Sparrow 2000; Bond & Midgley 2001; Bellingham & Sparrow 2009). It is often assumed that *Eucalyptus pauciflora* has a more or less unlimited capacity for continuous resprouting because lignotubers comprise a bud bank formed during the early stages of development which is retained throughout the life of the tree (Carr *et al.* 1984). To test this capacity and to examine the degree to which a regime of recurrent fire influences above ground stand structure, snow gum forests and woodlands were compared on three subalpine mountains with different fire frequencies – Lake Mountain after a single fire, a long-unburnt stand at Mt Buffalo, stands unburnt since 1939 at Mt Baw Baw and stands burnt in recurrent fires since 1970 at Mt Buffalo.

Study areas

The three study areas consist of dissected plateaux below 1700 m ASL and isolated from the more contiguous and extensive alpine and subalpine areas of the Great Dividing Range (Rowe 1970; Ashton & Hargreaves 1983; McDougall & Walsh 2007) (Figure 1). The Lake Mountain plateau is the smallest of the three and Mt Baw Baw plateau the most extensive, although average plateau height is similar (Table 1). All three mountains are composed of granitic parent material: granite at Mt Buffalo, granodiorite at Mt Baw Baw and rhyodacite at Lake Mountain.

Table 1. Maximum and average elevations and area of plateaux on each of the three mountains.

Mountain	Max height (m ASL)	Average height (m ASL)	Plateau area (ha)
Lake Mountain	1,482	1,348	2,352
Mt Baw Baw	1,565	1,378	6,941
Mt Buffalo	1,693	1,395	5,757

Livestock grazing occurred from the early days of European settlement until leases were terminated in 1958 (Mt Buffalo), 1964 (Lake Mountain) and 1978 (Mt Baw Baw). Mt Buffalo has the longest and most intense history of land use by Europeans and various areas of the plateau have experienced a range of disturbances since the mid-19th century (Webb & Adams 1998).

The three mountains represent a climate gradient from southern areas subject to oceanic influences, to more continental northern and inland areas. All have high annual rainfall which persists as snow at upper elevations for up to about four months during winter and early spring. Mean annual precipitation is around 1600–1900 mm (Ashton & Hargreaves 1983; McKenzie 1997). BIOCLIM estimates (Nix 1986) of mean annual temperatures indicate a range between 6.5°C and 10.4°C (McKenzie 1997). At Mt Baw Baw, mean annual precipitation is around 1540 mm and mean annual temperatures are 5.7°C to 6.2°C (Kershaw *et al.* 1993). Mean annual precipitation at Mt Buffalo is 1856 mm and strongly seasonal relative to the other two mountains. Mean annual minimum and maximum temperatures are 5°C and 11.7°C respectively, although lower temperatures would be expected in the high valley plains owing to cold air drainage from the adjacent slopes (Rowe 1970).

Numerous bushfires have been recorded throughout the study areas since 1850 (Zylstra 2006) but in many cases their precise localities are not known and it is not possible to reconstruct fire histories prior to 1939. However, parts of Mt Baw Baw National Park were probably burnt in 1923/24 and extensively burnt in 1939. Parts of Mt Buffalo appear to have been burnt in 1923/24 or 1926 and to a minor extent in 1939 (Hodgson 1927; Rowe 1970; Zylstra 2006). Lake Mountain plateau was burnt in 1939 (Ashton & Hargreaves 1983; Zylstra 2006; Shannon & Morgan 2007). Graziers are also believed to have lit fires to promote 'green pick' but these fires are not documented and their frequency, severity and extent are unknown.

Recent fire histories since 1970 differ markedly between mountains. Lake Mountain was burnt at high fire severity during the 2009 bushfires. The Mt Buffalo plateau was entirely burnt in 2003 and parts were burnt in 1972, 1985, and 2006/07 (Coates et al. 2012). Mt Baw Baw has remained unburnt since the 1939 bushfires and is currently the only substantial subalpine area in Victoria that has not been burnt since 2003 (Shannon & Morgan 2007; Coates *et al.* 2012).

Snow gum forests dominated by *Eucalyptus pauciflora* subsp. *pauciflora* or *Eucalyptus pauciflora* subsp. *acerina* Rule (endemic to Mt Baw Baw; Rule 1994) occur on upper slopes, crests and rocky rises but occupy similar niches and display similar physiognomy. Lower strata composition varies within and between sites according to degree of rockiness and soil depth, aspect, cold air drainage and time since fire. Shrubs are dominant on shallow soils, while grasses dominate on deeper soils.

Methods

Study design and field methods

The Point-Centred Quarter method (Cottam & Curtis 1956) was used to estimate stem density, stem frequency and total basal area of *Eucalyptus pauciflora* trees at each mountain along 300 m transects which were either continuous or segmented depending on the terrain.

Table 2. Site names, locality, fire history, number of transects and number of trees measured at each mountain.

Stem age is calculated from known fires.

LM1=Lake Mountain Site 1; LM2=Lake Mountain Site 2; BB1=Mt Baw Baw Site 1; BB2=Mt Baw Baw Site 2; PVO=Parks Victoria Office; Mt Dunn=Mt Dunn area; Mt McLeod=Mt McLeod area; 5 Acre Plain=Five Acre Plain area.

Mountain	Site	Latitude	Longitude	Fire history	Altitude (m)	Number of fires since 1938	Time since fire (y)	Number of transects	Number of trees measured	Alive stem age (y)	Dead stem age (y)
Lake Mountain	LM	37° 28' 44" S	145° 52' 37" E	1939	1440	2	2	2	200	–	70
	LM2	37° 29' 28" S	145° 52' 55" E	2009							
Mt Baw Baw	BB1	37° 50' 17" S	146° 15' 58" E	1939	1500	1	72	2	200	72	–
	BB2	37° 50' 6" S	146° 16' 23" E		1500						
Mt Buffalo	PVO	36° 43' 30" S	146° 48' 7" E	unknown	1400	0?	unknown	1	100	>70	–
Mt Buffalo	Mt Dunn	36° 43' 52" S	146° 46' 44" E	2003 2006	1410	2	5	1	100	5	3
Mt Buffalo	Mt McLeod	36° 41' 28" S	146° 46' 55" E	1972 2003	1410	2	8	1	80	8	31
Mt Buffalo	5 Acre Plain	36° 44' 10" S	146° 45' 47" E	1972 1985 2003 2006	1430	4	5	1	100	5	13 19 3

At Lake Mountain and Mt Buffalo, transects were located between 1400 m and 1440 m ASL (Table 2). Two sites were sampled at Lake Mountain west of Triangle Junction (Table 2). Sites sampled at Mt Buffalo were near the Parks Victoria Office (PVO), Mt Dunn, Mt McLeod and Five Acre Plain (Table 2). Fire frequency count ranged from no fires to four fires since 1970 (Table 2). Two sites with a fire frequency of 2 were sampled at Mt Buffalo because the inter-fire interval differed markedly at each site and no suitable sites were located with a fire frequency of 1 or 3. None of the sites selected at Mt Buffalo were known to have been burnt in 1939. The Mt Baw Baw transects were at higher elevations (1500 m–1550 m), located north-east of the Baw Baw Ski-village (Table 2). Transects were selected randomly within burnt areas so that aspect varied within sites. Fieldwork was carried out in February and March 2011.

One hundred trees were randomly sampled along each of two transects per fire frequency class, except at Mt Buffalo where one transect was sampled per fire frequency class. No two points were <10 m apart, to avoid the same tree being measured repeatedly. Fifty points (=200 trees) were sampled at Mt Baw Baw and at Lake Mountain. At Mt Buffalo 25 points (=100 trees) were sampled at each site, except at Mt McLeod where 20 points were sampled (=80 trees) owing to extremely dense vegetation (Table 2).

The distance from the sample point centre to the closest tree and seedling in each of four quarters was measured to the nearest 0.1 m. Where trees were multi-stemmed, distance was measured from each point to the centre of the lignotuber. On each tree, stem diameter at breast height over bark (D_{130} – approximately 130 cm above ground level) was recorded for all live and dead stems greater than 1 cm diameter. Dead stems which had broken away from the main clump and were lying on the ground were also measured. The diameter measures on dead stems were under bark diameters, as burnt bark had fallen from the trees after the fires. This is not expected to impact results to any serious extent as snow gum bark is relatively thin and the diameter classes used in the data analysis are relatively coarse. A general linear relationship between diameter and age was assumed for the present study although this is likely to have varied to some degree (Barker 1988; Wimbush & Forrester 1988; Wearne & Morgan 2001; Rumpff *et al.* 2009).

Some multi-stemmed trees at Mt Buffalo had arisen from extremely large lignotubers (1–2 m diameter), or the remains of lignotubers where parts had decayed and divided into separate clumps. This has been previously recorded in multi-stemmed trees (Barker 1988; Lacey & Johnston 1990; Dahdouh-Guebas & Koedam 2006). In these cases, an attempt was made to detect whether there was a connection between lignotuber sections by excavation and the clump closest to the sample point centre was measured, although in some cases this was not precise.

At Lake Mountain, 100% of trees were burnt in 2009, so measurements were an estimate of pre-fire population structure. Unburnt trees at Mt Baw Baw were an estimate of post-1939 population structure.

Seedlings were recorded as present if they occurred within twice the distance from the sampling point to the nearest tree in each quarter. Given the density of vegetation at some sites it was not practical to search beyond this distance. It was not possible to estimate seedling density using the Point-Centred Quarter method as seedlings were not found at each sample point. Hence, only the frequency of occurrence of seedlings per sample point was calculated. Presence or absence of fruits was recorded for each tree as an estimate of the frequency of reproductive adults.

Analytical methods

Stand structure and demography (tree density, mean number of stems, mean stem diameter, total basal area and relative basal area) were analysed according to the methods of Cottam & Curtis (1956). The percent frequencies of occurrence of seedlings and reproductive adults were the total number recorded divided by the number of quarters. Sites at Mt Baw Baw contained trees with only living stems and at Lake

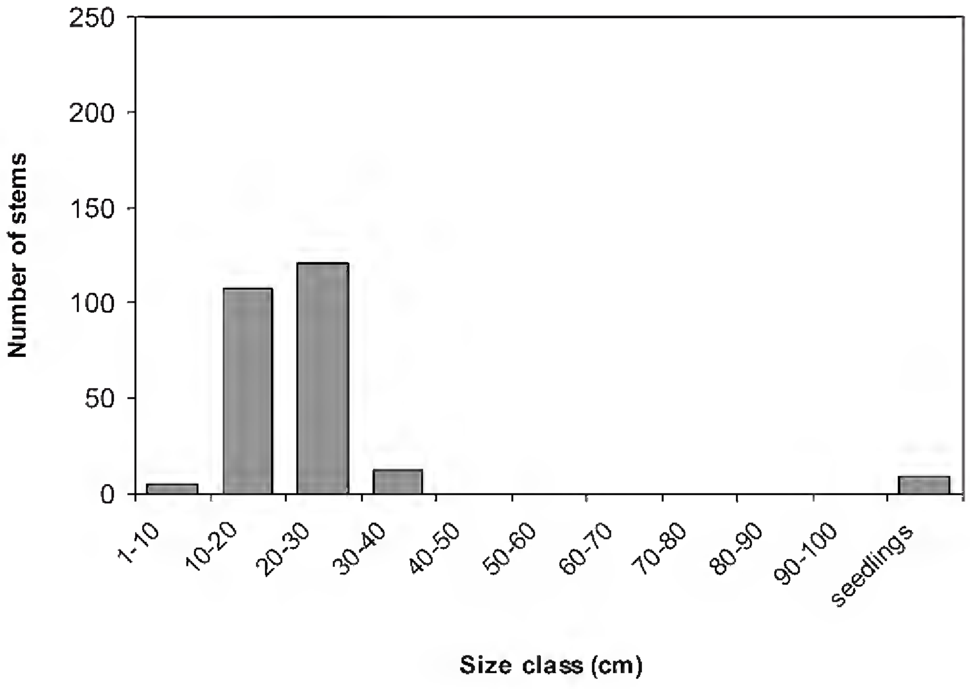

Fig. 2. Frequency of stem diameter size classes and seedlings at Mt Baw Baw (BB1). The site was last burnt in 1939.

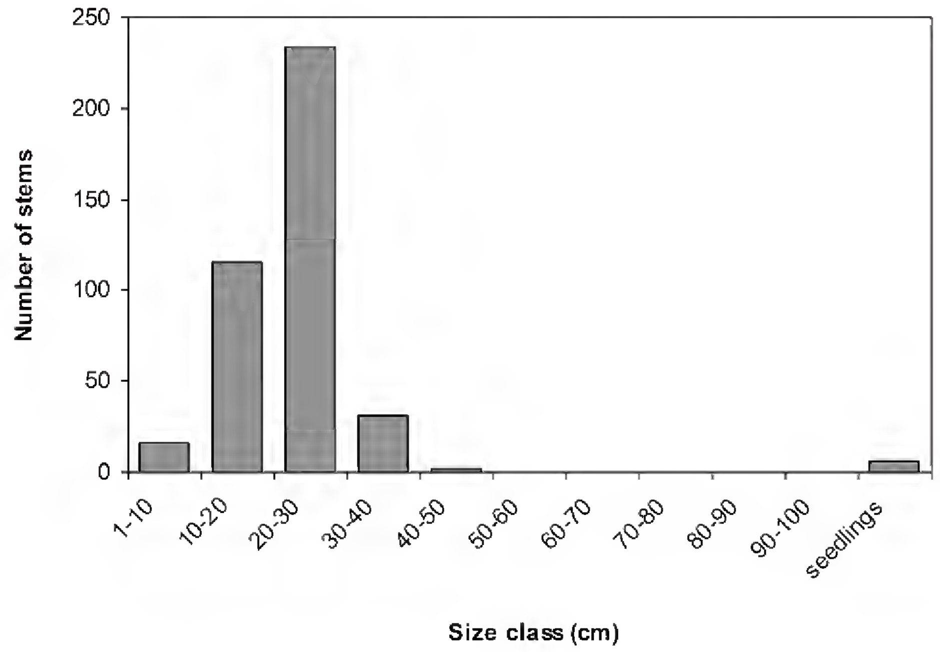

Fig. 3. Frequency of stem diameter size classes and seedlings at Mt Baw Baw (BB2). The site was last burnt in 1939.

Table 3. Tree density, mean number of stems and mean stem diameter of alive and dead stems as an estimate of pre-fire and post-fire stand structure at sites burnt since 2003, compared with unburnt sites. Tree density is the number of trees per hectare. Unburnt sites occurred at Mt Baw Baw (BB1, BB2) and Mt Buffalo (PVO). Fire frequency is calculated since 1938 to include the 1939 fires. LM1=Lake Mountain Site 1; LM2=Lake Mountain Site 2; BB1=Mt Baw Baw Site 1; BB2=Mt Baw Baw Site 2; PVO=Parks Victoria Office; Mt Dunn=Mt Dunn area; Mt McLeod=Mt McLeod area; 5 Acre Plain=Five Acre Plain area.

Site	Number of fires since 1938	Fire history	Tree density (trees/ha)	Pre-fire total basal area (dead stems m^2/ha)	Relative pre-fire basal area (%)	Post-fire total basal area (alive stems m^2/ha)	Relative post-fire basal area (%)	Mean (±SD) number of pre-fire stems/individual (dead stems)	Mean (±SD) number of post-fire stems/ individual (alive stems)	Frequency of seedlings (%)	Frequency of fruiting adults (%)
LM1	2	1939 2009	651	83	31	0	0	2±1	0	100	0
LM2	2	1939 2009	678	54	20	0	0	2±2	0	87	0
BB1	1	1939	445	0	0	70	33	0	4±2	6	91
BB2	1	1939	638	0	0	55	28	0	3±2	9	87
PVO	0?	unknown	821	0	0	33	16	0	1±0.4	77	81
Mt Dunn	2	2003 2006	1,468	48	18	2	1	3±2	4±4	3	44
Mt McLeod	2	1972 2003	1,333	54	20	26	14	7±6	17±11	35	33
5 Acre Plain	4	1972 1985 2003 2006	2,246	32	14	13.7	7	4±4	9±8	56	65

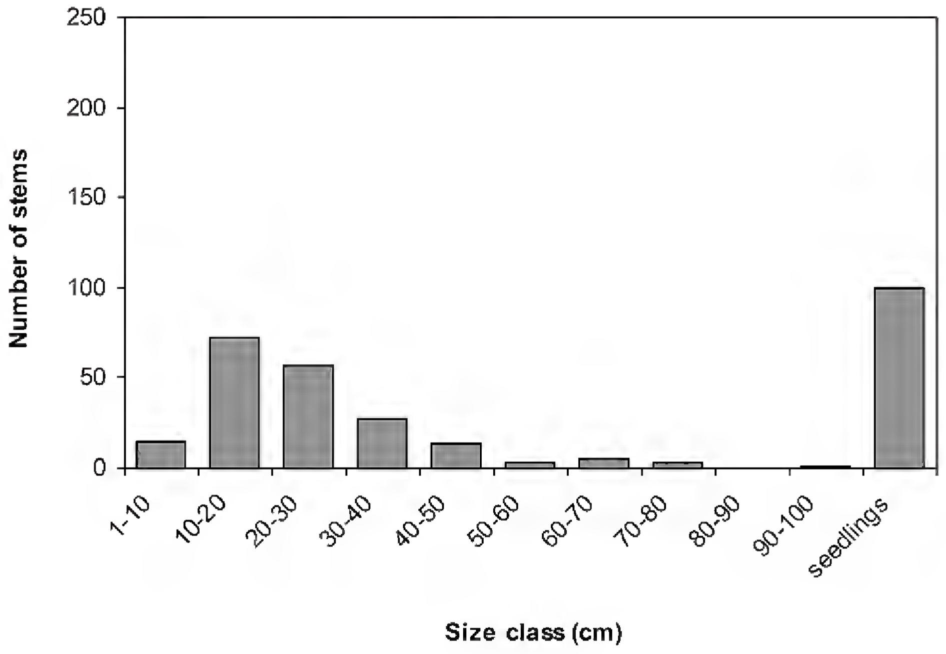

Fig. 4. Frequency of stem diameter size classes and seedlings at Lake Mountain (LM1). The site was burnt in 1939 and 2009.

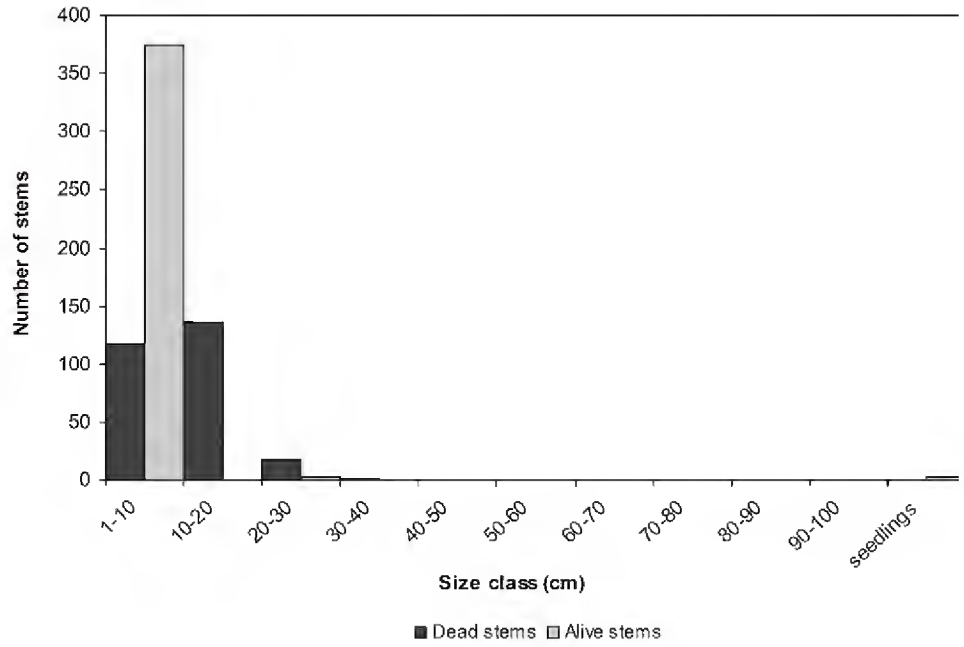

Fig. 7. Frequency of stem diameter size classes and seedlings at Mt Buffalo – Mt Dunn site. The site was burnt in 2003 and 2006.

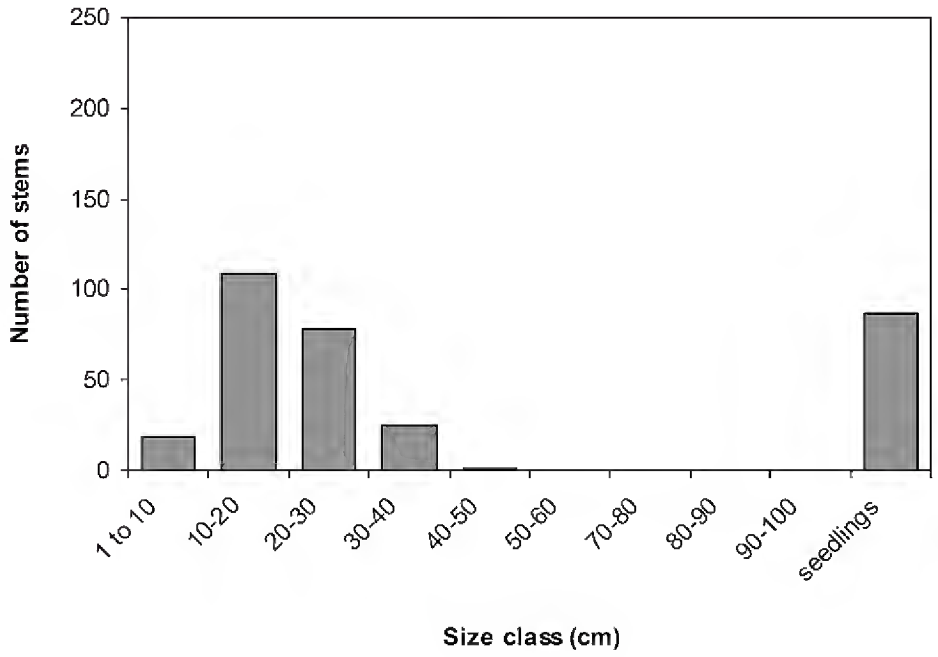

Fig. 5. Frequency of stem diameter size classes and seedlings at Lake Mountain (LM2). The site was burnt in 1939 and 2009.

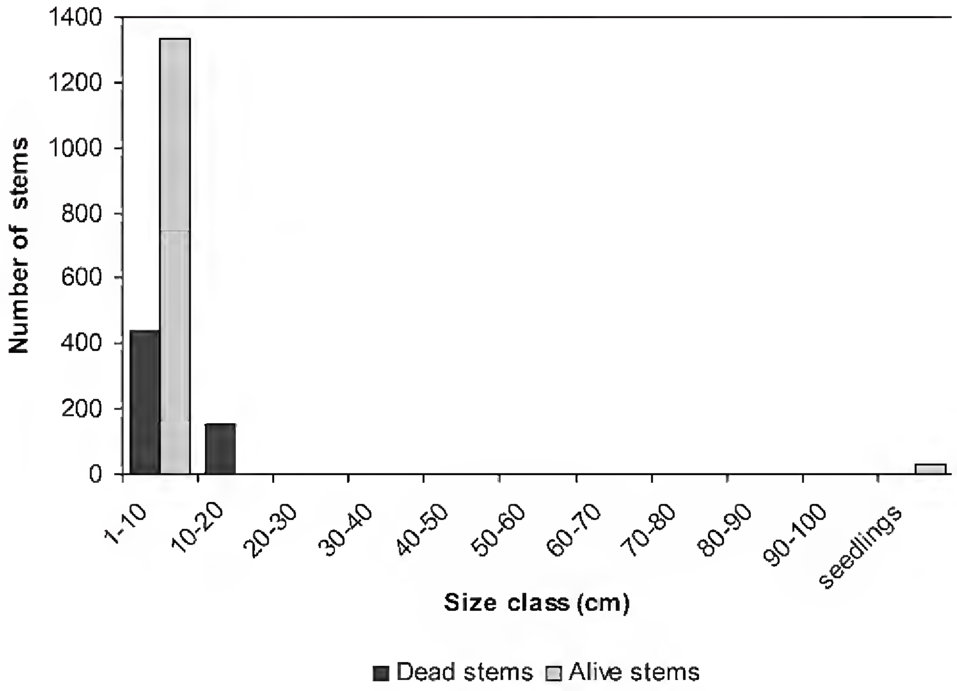

Fig. 8. Frequency of stem diameter size classes and seedlings at Mt Buffalo – Mt McLeod site. The site was burnt in 1972 and 2003.

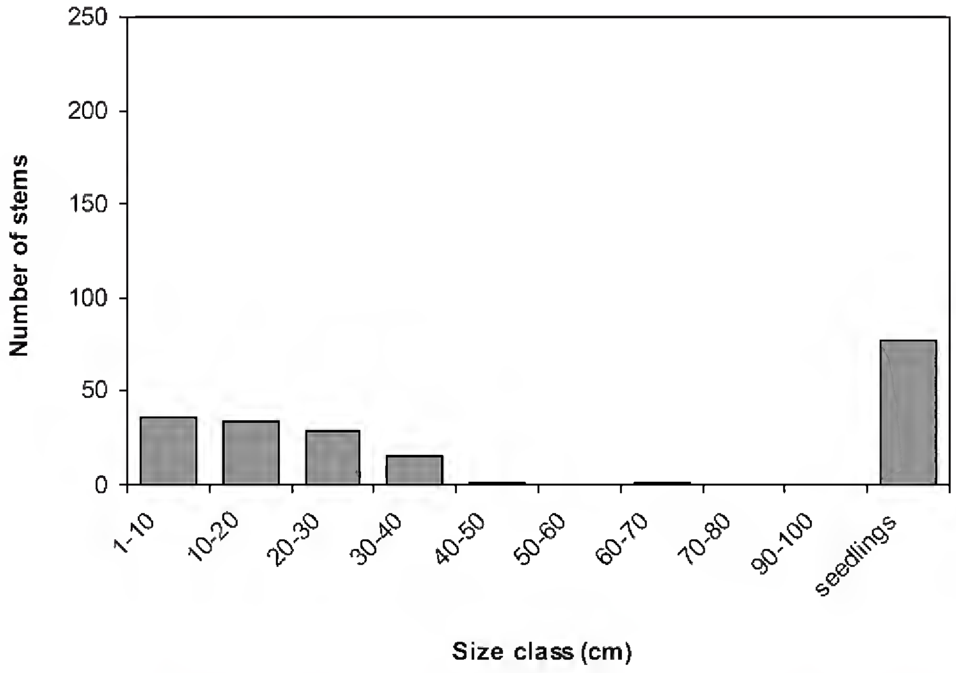

Fig. 6. Frequency of stem diameter size classes and seedlings at Mt Buffalo PV Office site (PVO). There is no recorded history of fire.

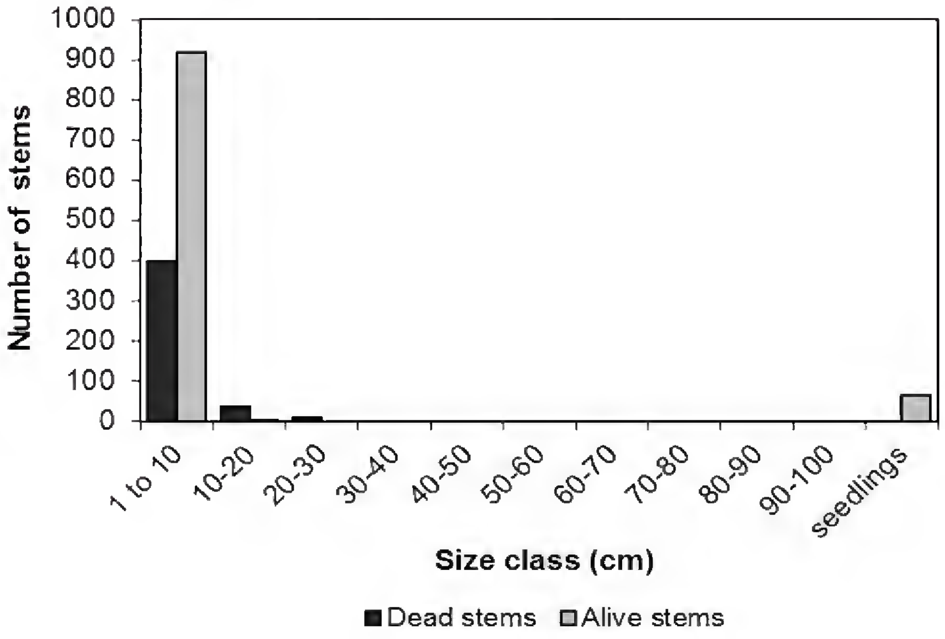

Fig. 9. Frequency of stem diameter size classes and seedlings at Mt Buffalo – Five Acre Plain site. The site was burnt in 1972, 1985, 2003 and 2006.

Mountain, only dead stems >D_{130}. At Mt Buffalo, multi-stemmed trees consisted of both dead and living stems. Dead stems were assumed to have arisen after one fire and then been killed by a subsequent fire (i.e. had clearly been burnt). The age of stems was calculated as the time between one fire and the next, or the time elapsed since the last fire. Separate calculations were carried out for dead and live stems at each site to estimate pre- and post-fire structure, respectively.

For each transect, stems were allocated to 10 cm D_{130}, size classes. Histograms of the frequency distributions of classes were compiled for each stand, representing pre-fire and post-fire population structure. The Kruskal-Wallis test was used to compare pre- and post-fire stem density, mean stem diameter and total basal area at each site, using Minitab® 16.1.0 Statistical Software (Minitab Inc. 2010). Results were considered significant if $P < 0.05$.

Results

Tree density, basal area, stem density and stem size

Long-unburnt sites (Mt Baw Baw, Mt Buffalo PVO) and Lake Mountain

Tree density was broadly similar at Mt Baw Baw and Lake Mountain and slightly higher at the long-unburnt Mt Buffalo PVO site (Table 3). Tree density at Lake Mountain was considerably lower than recorded by Ashton and Hargreaves (1983) at 23 years after fire (1072 trees ha^{-1}).

Total basal area at Mt Baw Baw was roughly equivalent to pre-fire total basal area at Lake Mountain (Table 3). However, total basal area at Mt Buffalo PVO was about half that of stands on the other two mountains (Table 3).

Mean number of stems at Mt Baw Baw and Lake Mountain was 2 to 4 (Table 3) although occasionally up to nine stems were recorded at Mt Baw Baw. At the long-unburnt Mt Buffalo PVO site, trees were single-stemmed (Table 3) and occurred with *Eucalyptus dalrympleana* as an occasional co-dominant. Pre-fire mean number of stems at Lake Mountain was lower than recorded 43 years after the 1939 fires (2 *cf.* 2.9) by Ashton & Hargreaves (1983).

Stand structure at Mt Baw Baw indicated recruitment following a major disturbance. The majority of stems were 20–30 cm D_{130} at BB1 and in the 10–20 cm D_{130} and 20–30 cm D_{130} classes at BB2 (Figure 2). Variability in tree and stem density across sites suggests differing disturbance histories. There were large trees (30–40 cm D_{130}) at both sites as well as a few very large trees (> 40 cm) recorded at BB1. There were few stems below 10 cm D_{130} at both BB sites (Figure 2).

Pre-fire structure at LM1 consisted of a range of size classes including some very large trees (>40 cm D_{130}) which were mostly absent from LM2. Most stems at both sites fell within classes 10–20 cm D_{130} or 20–30 cm D_{130} (Figure 3).

Stand structure at Mt Buffalo PVO comprised mostly single-stemmed trees and was consistent with its history of no recorded fire, although fire scars at the base of some trees suggested that the site had been burnt at some time in the past. Size classes were more or less evenly distributed (Figure 4). There were a couple of very large trees (>40 cm D_{130}), suggesting that this stand has been established for a very long time.

Multi-burnt sites (Mt Buffalo)

Tree density was up to five times higher at the three multi-burnt sites compared with Lake Mountain and the long-unburnt sites at BB and PVO and was particularly high at Five Acre Plain (Table 3).

In the short time that had elapsed since the last fires in 2003 and/or 2006, post-fire total basal area was significantly lower than pre-fire total basal area at all three sites ($P < 0.05$; Table 3). Total basal area had recovered to roughly half pre-fire levels at Mt McLeod and Five Acre Plain but was still very low at Mt Dunn (Table 3). Mt Dunn and Five Acre Plain, both burnt twice within three years, had the lowest pre-and post-fire total basal areas (Table 3).

At Mt McLeod and Five Acre Plain, the mean number of post-fire stems was significantly higher than the number of pre-fire stems ($P < 0.0001$) but numbers were higher at Mt McLeod (Table 3). There was a great deal of variation between trees at both of these sites, with stem numbers ranging from one to 49.

Pre- and post-fire stand structure at the most frequently-burnt site, Five Acre Plain, both consisted of numerous small stems (<10 cm $D_{130;}$ Figure 7). Very few larger burnt stems (>20 cm D_{130}) were measured. Pre-fire stems were assumed to be a mix of resprouts from 1972, 1985 and 2003, although it is possible that some stems killed in earlier fires had since been completely incinerated by 2006 and were no longer detectable. Thus, multiple regeneration events may not be completely represented and pre-fire estimates may mostly reflect 2003 structure.

At Mt McLeod, living stems which had resprouted after the 2003 fire were all <10 cm D_{130} (Figure 6). Stems which had resprouted after the 1972 fire and were burnt by the 2003 fire were also small (<10 cm D_{130}) although some larger stems were also measured (10–20 cm D_{130}).

There was little change between the low number of pre- and post-fire stems at Mt Dunn (Table 3). Dead stem numbers per tree at Mt Dunn ranged from one to 10 whilst live stem numbers ranged from one to 21 but only 10% of the trees measured had more than five living stems. Overall stand structure implied stems from three generations. Most post-2003 resprouts were killed in the 2006 fire and the current stand was composed almost entirely of thin stems <10 cm D_{130} which had resprouted after 2006 (Figure 5). A small number of burnt and living stems was recorded in size classes 20–30 and 30–40 cm D_{130} (Figure 5). The large, living stems had survived both the 2003 and 2006 fires, suggesting patchy fire coverage at this site. However, in comparison with the other sites, there was a higher number of burnt stems in the

10–20 cm D_{130} class than would be expected after only three years growth (between 2003 and 2006). This suggests that pre-fire structure may have included stems burnt in some unrecorded fire prior to 2003.

Reproduction

Seedlings were most frequent at Lake Mountain and Mt Buffalo PVO (Table 3; Figures 2, 3 and 6). Continuous recruitment was occurring at Mt Buffalo PVO in long-unburnt snow gum forests with a high number of reproductive adults, whilst at Lake Mountain a pulse of recruitment occurred following the 2009 fire. In spite of a high proportion of fruiting adults at Mt Baw Baw, seedling recruitment was very low (Table 3; Figures 4 and 5). Seedling recruitment was highest in stands with high stem numbers (Mt McLeod and Five Acre Plain; Table 3; Figures 8 and 9) and lowest at Mt Dunn (Table 3; Figure 7), even though the frequency of fruiting adults was substantial at the latter site.

Discussion

Stem density at Lake Mountain was consistent with the prediction of Ashton & Hargreaves (1983) that stem thinning would occur in the absence of fire. Stem density was slightly higher at Mt Baw Baw but still within expected ranges 70 years after fire. Similar total basal areas at Lake Mountain and Mt Baw Baw imply that stand structure developed along similar trajectories until the most recent fire in 2009 and it is almost certain that pre-fire stand structure will not be restored at Lake Mountain for at least another 70 years. Predicted climate change impacts of lower rainfall and higher fire frequency (Parry *et al.* 2007) may mean that recovery of pre-fire structure may take longer.

Stand structure at Mt Buffalo PVO was consistent with a long fire-free period but mean stem diameter was lower compared to trees at other sites. This is most likely a consequence of faster stem growth owing to more favourable site conditions (e.g. climate, water availability, soil depth or fertility) and hence taller, more slender trunks consistent with tree physiognomy at lower altitudes. *Eucalyptus dalrympleana* was an occasional co-dominant, indicating that frost and snow cover are lighter relative to sites where snow gum is the sole dominant (Farrell and Ashton 1973). However, since the time of the last fire is unknown, thinner stems may also be a consequence of a more recent, unrecorded fire.

In addition to recent high fire frequency, escaped fires from deliberate burning by graziers prior to 1958, as well as shallow soils, may have contributed to current high stem numbers and high tree density at Five Acre Plain. More recently, control of rabbits, known to kill basal shoots through ringbarking (Wimbush & Forrester 1988), may also have promoted multiple stem development.

At Five Acre Plain, stems were all within the smallest size class and pre- and post-fire total basal area was low in spite of high post-fire stem numbers, suggesting that above ground carbon storage may be constrained when there is investment in numerous small stems. Since at least 1970, trees at this site have probably remained in the ‘proliferative’ growth phase characteristic of post-fire coppicing (Noble 2001). High tree density at this site also suggests that intraspecific competition may constrain biomass accumulation (Bellingham & Sparrow 2000), since natural thinning in stands with high stem densities and a mallee habit seems to occur at a lower rate than within open forest (Barker 1988).

Grazing by cattle, sheep and rabbits has been credited with suppressing post-fire stem and seedling regeneration in alpine snow gum forests in some more elevated locations on deeper soils such as in Kosciusko National Park and the Bogong High Plains (Bryant 1971; Wimbush & Forrester 1988; Rumpff 2008). Prior to 1958, cattle probably occupied the area around Five Acre Plain, where salt was left for cattle before the autumn muster (Webb & Adams 1989). However, it is doubtful that stock accessed the relatively dry, rocky terrain at the site, or preferentially grazed the shrubby strata over more herbaceous vegetation around low lying terrain. There is no record of sheep grazing at Mt Buffalo.

Pre-2006 fire structure at Mt Dunn consisted of few-stemmed trees but relatively high total basal area. The grassy stratum at this site is suggestive of deeper soils and higher site productivity. Some large stems (burnt and living) were recorded. However, there were a number of burnt stems recorded in the 20–40 cm D_{130} classes and total pre-fire basal area was comparable with LM2. The most likely explanation for stems of this size is patchy fire history at this site and that stand structure includes stems which originated after one or more unrecorded fires prior to 1958, around the time o f cattle grazing.

The mallee form and numerous thin stems at Mt McLeod suggest that this site was also burnt in unrecorded fires prior to 1972. Its location on the northwest part of Mt Buffalo would expose this site to bushfires, which typically occur on days of strong northerly winds, such as the severe fires of 1972 and 2003 (Dexter 1973; Coates *et al.* 2006). Soils are relatively shallow and rocky, which would also promote a mallee growth form. Lignotubers of most trees that were measured were very large (up to 2 m diameter), suggesting long-term dominance of lignotuber growth over stem growth, as can occur when secondary lignotubers fuse laterally (Carr *et al.* 1984). Stem clumps were distributed in wide rings, consistent with descriptions in the literature of repeated resprouting after the upper lignotuber surface is killed and new growth is initiated at the periphery (Lacey & Johnston 1990). The lack of stems in size classes greater than 10–20 cm D_{130} adds further weight to the notion that multi-stemmed trees have prevailed at this site for a long time.

There is no record in the available literature to confirm that Mt McLeod was ever grazed (e.g. Rowe 1970; Binder 1978; Stephenson 1980; Webb & Adams 1998) and it is unlikely that cattle occupied this remote site, where access is difficult.

Thus, the influence of cattle grazing on stand structure is likely to have been insignificant.

Stand regeneration

With the exception of the stand PVO, all the stands measured show pre-fire size/age structures which indicate pulse regeneration following a major disturbance. In contrast, stand PVO has a size/age structure which appears to indicate more or less continuous regeneration.

At Lake Mountain and Mt Baw Baw stand structure is indicative of regrowth after the 1939 fire. The very large/old individuals present at LM1 tend to suggest that these stems were not destroyed in the previous fire in 1939, unlike in 2009 when 100% of trees were burnt at extremely high intensity. In contrast with a relatively heterogeneous pre-fire structure, snow gum forest at Lake Mountain will comprise stands of even-aged stems for the foreseeable future.

At Mt Dunn, the few trees recorded in the 10–20 cm and 20–30 cm D_{130} size classes imply that this site may have been burnt in 1939 but regeneration has since been poor and there are no living stems which pre-date the 1939 fire. At other multi-burnt Mt Buffalo sites, there were almost no stems >20 cm D_{130}. The size-class range of dead stems at these sites suggests that stems of all diameters can be killed during a fire so that stem size is unlikely to be useful for re-constructing fire severity. Large stems which had survived some fires were occasionally recorded but these were rare. Because snow gum bark is thin throughout the lifespan of the tree (Williams & Ashton 1988), snow gum stems may be more vulnerable to low intensity fires than most other eucalypt species.

Seedling recruitment

Ashton & Hargreaves (1983) reported high seedling densities 23 years after fire at Lake Mountain. These densities later diminished with natural thinning and interspecific competition. The current cohort of seedlings on Lake Mountain is expected to decline with regrowth of competing understorey vegetation and natural attrition. Seedling frequency was low at Mt Baw Baw in forest with dense shrubs but was relatively high at PVO where the lower strata are open. However, the lack of individuals in the mid-storey at PVO implies that these seedlings are likely to persist in a suppressed state (Ashton & Williams 1989; Loehle 2000) until canopy disturbance creates growing space.

The very low seedling frequency at Mt Dunn is most likely a result of the short time between the two recent fires. However, the grassy ground stratum at this site also implies that seedlings which have been unable to compete effectively for resources may have been more vulnerable to frost or drought in the absence of an intact canopy in the years after fire (Wearne & Morgan 2001; Loveys *et al.* 2010). Seedling recruitment was moderate at Five Acre Plain and Mt McLeod. Given patchy fire coverage in 2006 at Five Acre Plain and high rock cover at both of these sites, seedlings are likely to have been better protected.

How persistent is snow gum under a changed fire regime?

The ability to repeatedly resprout certainly suggests that snow gum is a tenacious 'niche persistor' (Bond & Midgley 2001). Such adaptation might have derived from limited opportunity for populations to expand in an environment where seedling establishment is constrained by snow and extreme frosts (Billings 1969; Loveys *et al.* 2010; Green & Venn 2012). Resprouting is an extremely effective means of replacing biomass after damage to adults (Loehle 2000) and as a long-term site occupancy strategy, even when intervals between disturbances are short (Bellingham & Sparrow 2000). In this study, we detected capacity for resprouting after four fires within four decades at one site. However, until recently snow gum has occupied landscapes with infrequent large-scale fires (Wahren *et al.* 2001) so that historically, complete destruction of above ground biomass and replacement of the entire crown by resprouting is likely to have been rare.

The results of this study demonstrate structural differences between long unburnt and frequently burnt snow gum stands, both within and between mountains. The two sites with the shortest inter-fire intervals (Mt Dunn and Five Acre Plain) also had the lowest post-fire total basal areas in spite of an increase in the mean number of stems, at least partly explained by the relatively short growth time between the last fire and the timing of the survey. However, at Five Acre Plain and Mt McLeod, the results also imply that multi-stemmed architecture has become entrenched as numerous small stems assume equal apical dominance and that large stems may never fully develop, even after a long fire-free period (Lacey & Johnston 1990).

The potential for snow gum stands to persist in the longer term under this switch in disturbance frequency is uncertain. Not examined in this study was the resprouting ability of very old trees which may already have sustained damage from previous fires, insects and pathogens. The response of such trees is currently unknown. Field observations suggest that there has been a trade-off between resources allocated to growth and reproduction rather than starch storage in lignotubers and a reduction in resprouting ability (Bond & Midgley 2001), also observed in some *Eucalyptus camaldulensis* populations under regimes of infrequent disturbance (Jahnke et al. 1983). As a consequence, with increasing age, trees may be allocating an increasing proportion of their resources to growth and reproduction (by seed) than to starch storage and resprouting ability. The implications are that some old trees may never be replaced after fire and that niche persistence is size/age limited, or can only be maintained under low frequency and low severity disturbance regimes. The current outlook is one of a radical demographic shift in snow gum population structure in subalpine landscapes.

Open snow gum stands provide the most effective means of water collection and regulation and repeated fire substantially impacts on their ability to sustain snow accumulation and persistence, retain soil moisture, prevent erosion (Costin 1967) and possibly to store carbon owing to reduced total basal area. Some of the only long-unburnt snow gum forests in Victoria occur at Mt Baw Baw and to a limited extent, at Mt Buffalo. Excluding fire from these areas is imperative to maintain these old growth stands.

Recent severe and widespread bushfires between 2003 and 2009 have seen the introduction of mandatory targets for fuel reduction burning across Victoria's public lands to mitigate the scale and impact of future unplanned fires. Fire severity data were not available to this study and stands burned by low-severity fuel reduction fires were not investigated. Conversely, the impact of stands with higher stem numbers and hence increased elevated fuel (Lentile *et al.* 2006) on fire severity has not been studied in subalpine forests in Victoria. Further work is also needed to determine these possibly unforeseen and additional consequences of changes in fire frequency in snow gum woodlands.

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The flora of Kosciuszko National Park, New South Wales: Summary and overview

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Abstract: Although Kosciuszko National Park is one of the largest and oldest in New South Wales, the vascular flora found within it has not been fully documented. An understandable focus on the alpine and subalpine flora has resulted in a lesser focus on the flora of the extensive tracts of forest and woodlands found in the montane, tableland and lower Snowy River zones of the Park. Here we summarise and provide an overview of the entire vascular flora across the full range of floristic zones within Kosciuszko, building upon earlier summaries focussed solely on the alpine and subalpine zones. Our compilation of records resulted in a total vascular flora for Kosciuszko National Park of 1435 taxa, of which 1105 taxa (77%) are native and 330 taxa (23%) are alien, excluding cultivated taxa. Based on 1990 data for the flora of New South Wales, Kosciuszko National Park hosts 24% of the State's native vascular flora and 26% of the State's alien vascular flora. There are 25 species of vascular plant that are endemic to the park and all but one (*Haloragis milesiae*) occur in the alpine and subalpine zones. A further 86 species have their NSW occurrences confined to the park. Many of the 24 endangered or vulnerable species found within the park also have their main occurrences in treeless subalpine and alpine vegetation. An additional 105 species are at the limits of their geographic distribution, have disjunct occurrences in the park or are uncommon in the Alps and these occur across a range of floristic zones. At least one species, *Euphrasia scabra*, is listed as presumed extinct in the park although it occurs elsewhere in New South Wales. Although well surveyed overall, areas including the Byadbo Wilderness, Pilot Wilderness and forests on the western flanks are by comparison under sampled and will require further survey effort in future to fully document the flora of the park. Historical legacies of past land use practices and impacts from current recreational uses, as well as impacts from feral herbivores and alien plant species all pose ongoing threats to the long term survival of many plant species found within the park. The interaction of these threats with increasing temperatures, shifting rainfall patterns including snow cover and changing fire regimes will require ongoing monitoring and increased resourcing if significant changes to ecosystems are to be effectively managed.

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Introduction

Kosciuszko National Park (KNP) is the largest national park in New South Wales and comprises 690,660 ha of diverse climates, geologies and vegetation types. Vegetation communities range from dry woodland and shrubland communities in the lower Snowy River area (Clayton-Greene & Ashton 1990; Pulsford *et al.*1993) through extensive tracts of montane forest and woodland communities, to the herbfields of the true alpine zone (Wimbush & Costin 1973; Costin *et al.* 2000) as well as unusual communities such as *Acacia* shrublands (Clayton-Greene & Wimbush 1988) and cool temperate rainforest (Doherty *et al.* 2011). Vegetation types and patterns found within KNP have been summarised broadly by Good (1992) and in more detail by Gellie (2005). The park has been the subject of botanical exploration and documentation since the late 1800s (Helms 1890; Maiden 1898; Maiden 1899). However, because the area contains the highest peaks in Australia and because true alpine areas in Australia are highly restricted (Costin 1957; Costin 1968; Costin 1981), much of the botanical focus within Kosciuszko National Park has been in the treeless alpine and subalpine zones (Wimbush & Costin 1973; Wimbush & Costin 1979a; Wimbush & Costin 1979b; Wimbush & Costin 1979c; McDougall & Walsh 2002; McDougall & Walsh 2007). Alpine and treeless areas represent less than 14% of the area of the park and the surrounding tracts of montane and tablelands forests and woodlands are much less documented and studied. This paper builds upon the work of Thompson and Gray (1981), which focussed on areas above 1500m, and extends coverage to the whole of KNP so as to provide a comprehensive record of all known vascular plant species.

Location, Biophysical Setting and History

The park is located in the Southern Tablelands Botanical Region of NSW and protects significant areas of the Australian Alps and South East Highlands Bioregions (IBRA 2004). The geology of the region is complex (see Bureau of Mineral Resources, 1990), but more than half of the reserve consists of Silurian and Devonian granitic rocks, particularly in the higher southern parts of the park, which have displaced Ordovician sediments to the west and to the east. A mixture of Ordovician, Silurian and Devonian volcanics and a series of faults run through the middle of the reserve from south west to north east, resulting in a complicated geology, particularly in the northern parts between the Long Plain Fault Zone and the Tantangara Fault. Small areas of Silurian Limestone also occur in this northern area (e.g. Yarrangobilly Caves, Blue Waterholes) as do occasional intrusions of Tertiary Basalt (e.g. east of Mt. Selwyn). An altitudinal range of over 2000 m, from 200 m asl in the lower Snowy River to 2228 m asl on Mt. Kosciuszko, gives rise to a wide range of climatic conditions (Table 1). Overall, the eastern fall of the reserve receives less precipitation than the central and western areas, due to a rain shadow effect and this is particularly the case in the lower Snowy River area.

Table 1. Modelled climatic ranges in Kosciuszko National Park (BIOCLIM 30 sec resolution) (Hijmans *et al.* 2005).

Climate Variable	Range
Mean annual temperature	**2.4–13.3°C**
Mean temperature of coldest month	-5.5–0.8°C
Mean temperature of warmest month	13.8–29.6°C
Mean annual precipitation	**590–2720mm**
Mean precipitation of driest month	34–128mm
Mean precipitation of wettest month	62–297mm

The area comprising what is now KNP was inhabited by the Walgalu, Djilamatang and Ngarigo Aboriginal tribal groups (Tindale 1974; Young, Mundy & Mundy 2000). Alpine and subalpine areas were used seasonally, particularly in relation to the harvesting of Bogong moths in summer (Flood 2010) whereas permanent and more intensive use was made of fertile areas at lower altitudes on the Tablelands, including the Snowy River Valley. European colonisation and subsequent settlement and exploration from the early 1800s onward led to a period of mixed land use ranging from gold mining and cattle and sheep grazing in the mid 19th to mid 20th centuries to intensive development for the Snowy Mountains Hydroelectric Scheme from the mid 20th century onward. There has also been concentrated development in subalpine areas for ski resort development since the 1970s. The core of the park was declared in 1944 as a State Park and a variety of additions over the subsequent decades and a change in status in 1967 to National Park have increased the park to over 690,000 ha. Although much of what is now Kosciusko National Park still retains relatively intact vegetation communities and a diverse flora, these past land uses have left a legacy of disturbances from grazing, clearing, logging and altered fire regimes. One legacy of these disturbances has been the establishment of populations of exotic plant species, naturalised either from the grazing era or resulting from plantings and introductions during the mining and hydroelectric development periods.

Methods

Thompson & Gray (1981) was used as the starting point for the list compilation. Collections were then examined from Australian herbaria via Australia's Virtual Herbarium http://avh.chah.org.au/, and the Waste Point Herbarium, Kosciuszko National Park, maintained by the New South Wales Office of Environment and Heritage. Taxa included in the list were primarily from herbarium specimens, but a small number of species were added based on authoritative sources where no specimen had been lodged (see Appendix 1). The list is current as of June 2014. Data on origin and use of alien species were obtained from the Germplasm Resources Information Network (http://www.ars-grin.gov/), accessed in August 2013. After compilation and vetting of

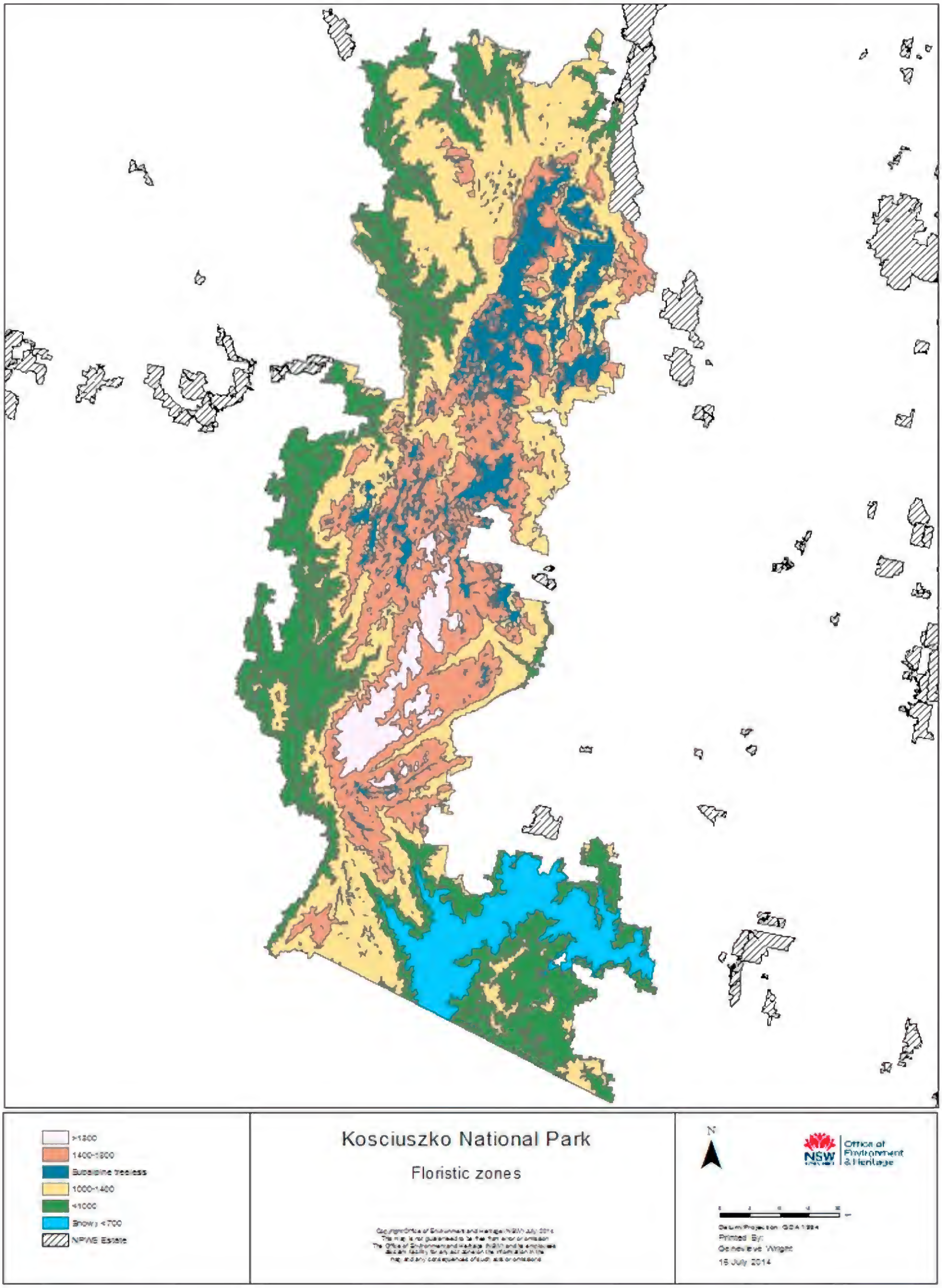


Fig. 1. Map of Floristic zones in Kosciuszko National Park.

Table 2. Floristic Zones in Kosciuszko National Park based on McRae (1989) and Good (1992), indicating area of each zone and sampling intensity of all vegetation surveys undertaken within it.

Floristic Zone	**Area (ha)**	**Area (as % of KNP)**	**Full Floristic Plots (No.)**	**Plot Density per 10,000 ha**
Lower Snowy < 700m (Dry Woodlands and Open Forests)	48200	7	46	9
Tableland Forest 400-1000m (Dry – Moist Forests)	186706	27	138	7
Montane Forest 1000m- 1400m (Moist – Wet Forests)	228743	33	239	10
Subalpine Snowgum 1400-1800m (Moist Woodlands and Open Forests)	139967	20	123	9
Subalpine/Montane Treeless < 1800m (Grasslands, Bogs, Fens and Heathlands)	62165	9	211	34
Alpine > 1800m (Herbfields, Feldmark, Grasslands, Bogs, Fens and Heathlands)	24879	4	148	59

Table 3. Number of native taxa in Kosciuszko National Park by taxonomic group and showing Dicot:Monocot ratios and taxa per 10,000 ha by whole of park and in relation to the area of each floristic zone separately.

	Whole of Park	Lower Snowy <700m	Tableland Forest <1000m	Montane Forest 1000–1400m	Subalpine Snow-gum 1400-1800m	Subalpine/Montane Treeless <1800m	Alpine >1800m
Total Taxa	**1105**	**253**	**464**	**475**	**301**	**436**	**240**
Ferns & Fern Allies	35	8	15	15	5	10	7
Gymnosperms	3	2	2	1	1	1	1
Monocots	302	59	115	118	76	138	74
Dicots	765	184	332	340	218	286	158
Dicot:Monocot Ratio	2.5:1	3.1:1	2.9:1	2.8:1	2.8:1	2.1:1	2.1:1
Taxa Per 10,000 ha	**16**	**52**	**25**	**21**	**21**	**70**	**96**

the list for taxonomic consistency and current accepted name using the Australian Plant Census (http://www.anbg.gov.au/chah/apc/), taxa were assigned to broad floristic zones based on McRae (1989) and Good (1992) (Figure 1; Table 2), using descriptive habitat information on herbarium labels, vegetation plot data held by Office of Environment and Heritage, incidental records, relevant publications, or from personal knowledge.

Results

The current total recorded vascular flora for KNP is 1435 taxa, of which 1105 taxa (77%) are native and 330 taxa (23%) are alien, excluding cultivated taxa (Appendix 2). Based on 1990 data for the vascular flora of NSW, Kosciuszko National Park hosts 24% (1105 / 4677) of the NSW native vascular flora and 26% (330 / 1253) of the NSW alien flora (http ://www.anbg.gov.au/aust-veg/australian-flora-statistics.html). The totals to date reflect both opportunistic and targeted non plot sampling as well as sampling undertaken during plot based vegetation studies. However, plot sampling in relation to the aerial extent of each floristic zone (Table 2) shows a strong bias towards treeless areas. With a maximum sampling density of 59 plots and a minimum of 7 plots per 10,000 ha, this indicates a very low number of plot samples in forested areas in KNP relative to the extent of these vegetation types.

Native Flora Summary

The native flora consists of 1105 taxa: 35 ferns and fern allies; 3 conifers; 765 dicots and 302 monocots. The highest numbers of native taxa occur in the mid altitudes (400-1800m) in the Tableland Forest, Montane Forest, and Subalpine/Montane Treeless plains, followed by Subalpine Snowgum and Alpine zones, with the lowest number of taxa recorded in the Lower Snowy zone (Table 3). Approximately 70% of the native taxa are dicots and overall, the ratio of dicots to monocots is approximately 2.5:1. This ratio is higher in forest communities (2.9:1) than in alpine and subalpine treeless communities (2.1:1), where the diversity and proportion of grasses and sedges increases. As a function of taxa per unit area, the Subalpine snowgum and Alpine zones have a significantly higher density of taxa per unit areas than the forested zones, apart from the Lower Snowy zone where taxa per unit area is also high (Table 3).

Approximately 70% of taxa occur in only one or two floristic zones in KNP (Table 4). This implies a strong environmental sorting of species and reflects the strong altitudinal gradients found in the park. Only 4 species occur in all 6 floristic zones. More than 50% of the native taxa are perennial forbs, 30% are shrubs or woody twiners and only 9% are perennial grasses (Table 5). Other life forms only constitute small numbers of taxa, with 4.2% being annual or biennial forbs

Table 5. Number of native taxa in Kosciuszko National Park by life form.

	TOTAL	Annual/Biennial Forb	Annual Grass	Perennial Forb	Perennial Grass	Shrub/Woody Twiner	Tree
Number	1105	40	7	592	98	330	38
Percentage	100	3.6	0.6	53.5	8.9	30.0	3.4

Table 6. Ten most numerous native plant families and genera in Kosciuszko National Park with number of taxa shown in brackets.

Rank	Dicot Families	Monocot Families	Dicot Genera	Monocot Genera
1	Asteraceae (159)	Poaceae (100)	*Eucalyptus* (31)	*Carex* (21)
2	Fabaceae (88) (Faboideae 58; Mimosoideae 30)	Orchidaceae (75)	*Acacia* (30)	*Pterostylis* (19)
3	Myrtaceae (52)	Cyperaceae (56)	*Senecio* (23)	*Rytidosperma* (18)
4	Ericaceae (28)	Juncaceae (25)	*Olearia* (21) *Ranunculus* (21)	*Juncus* (16) *Poa* (16)
5	Ranunculaceae (26)	Asparagaceae (8)	*Brachyscome* (16)	*Deyeuxia* (12)
6	Proteaceae (22)	Hemerocalidaceae (6)	*Pimelea* (15)	*Isolepis* (11)
7	Plantaginaceae (20)	Colchicaceae (3) Hypoxidaceae (3) Potamogetonaceae (3)	*Craspedia* (13)	*Thelymitra* (10)
8	Rutaceae (19)	Asphodelaceae (2) Asteliaceae (2) Iridaceae (2) Restionaceae (2)	*Geranium* (11) *Pomaderris* (11) *Pultenaea* (11)	*Luzula* (9) *Prasophyllum* (9)
9	Apiaceae (18) Lamiaceae (18)	Luzuriagaceae (1) Xanthorrhoeaceae (1)	*Leptospermum* (10) *Grevillea* (10)	*Agrostis* (8)
10	Rubiaceae (17)		*Veronica* (9) *Wahlenbergia* (9)	*Dichelachne* (6)

and grasses, and 3.4% being trees. Although trees dominate much of the vegetated area of KNP, their diversity is low.

The largest number of native taxa in a dicot family is found in the Asteraceae (159), with large numbers also in the Fabaceae (88 taxa) and the Myrtaceae (52 taxa). The largest number of taxa in a monocot family is found in the Poaceae (100 taxa), with large numbers also in the Orchidaceae (75) and Cyperaceae (56). At the generic level, the largest number of taxa within a single dicot genus is found in *Eucalyptus* (31 taxa) with *Acacia* also having a similar number (30). Monocot genera have their largest diversity in *Carex* (21 taxa) and *Pterostylis* (19 taxa) (Table 6).

Certain genera are characteristically found in montane or cold environments. Kosciuszko National Park conserves more than half of the taxa found in each of 26 NSW montane or cold climate genera: 11 Australasian, 5 southern hemisphere and 10 cosmopolitan, and all of the taxa that occur in the genera *Aciphylla*, *Argyrotegium*, *Parantennaria* and *Botrychium.* (Table 7).

There are 25 species of vascular plant that are endemic to KNP and all but one of these (*Haloragis milesiae*) occur in the alpine and treeless zones. A further 86 species have their NSW occurrences confined to KNP. Many of the 24 endangered or vulnerable species found within KNP also have their main occurrences in treeless subalpine and alpine vegetation (Table 8). An additional 105 species are at the limits of their geographic distribution, have disjunct occurrences in KNP or are uncommon in the Alps (Table 9) and these occur across a range of floristic zones. One species, *Euphrasia scabra,* is listed as presumed extinct in KNP although it occurs elsewhere in NSW. It was last collected in KNP at Yarrangobilly Caves in 1897. Additionally, although *Irenepharsus magicus* is listed as Endangered, the last and only collection of this species in KNP was in the Geehi area in 1954, so it too may be extinct in KNP.

Table 7. Genera with more than half of NSW taxa in Kosciuszko National Park.

Genus	Taxa in KNP	Taxa in NSW	Taxa in Australia
1) Australasian genera with greatest diversity in montane or cold environments			
Aciphylla (Apiaceae)	2	2	2
Acrothamnus (Ericaceae)	3	3	4
Argyrotegium (Asteraceae)	4	4	4
Celmisia (Asteraceae)	4	5	9
Craspedia (Asteraceae)	13	14	26
Dichosciadium (Apiaceae)	1	1	2
Ewartia (Asteraceae)	1	1	4
Parantennaria (Asteraceae)	1	1	1
Rhytidosporum (Pittosporaceae)	3	5	5
Richea (Ericaceae)	1	1	12
Schizeilema (Apiaceae)	1	1	1
2) Southern hemisphere genera, with greatest diversity in montane or cold environments (also Hawaii for ***Oreomyrrhis*** and Pacific area for ***Astelia***)			
Abrotanella (Asteraceae)	1	1	3
Astelia (Asteliaceae)	2	2	5
Carpha (Cyperaceae)	2	2	4
Colobanthus (Caryophyllaceae)	4	5	10
Oreomyrrhis (Apiaceae)	5	5	7
3) Cosmopolitan genera, with high diversity in montane or cold environments			
Botrychium (Ophioglossaceae)	2	2	2
Cardamine (Brassicaceae)	7	10	15
Deschampsia (Poaceae)	1	1	4
Erigeron (Asteraceae)	5	5	10
Euchiton (Asteraceae)	6	6	9
Luzula (Juncaceae)	9	12	19
Poa (Poaceae)	16	25	40
Ranunculus (Ranunculaceae)	22	31	45
Scleranthus (Caryophyllaceae)	5	8	8
Uncinia (Cyperaceae)	5	7	7

Alien Flora Summary

The alien flora of Kosciuszko National Park comprises 365 taxa, 35 of which are regarded as in cultivation only (and mostly found in Thredbo ski village in the Subalpine Snowgum zone). The following results include only the 330 non-cultivated taxa.

The highest number of alien taxa was recorded at mid altitudes in tableland forest, montane forest and snow gum woodland; the fewest taxa were recorded in the alpine zone. About three-quarters of alien taxa are dicots (Table 10). There are very few gymnosperms except at mid elevations where most have naturalised from plantations grown before the area was reserved for nature conservation.

Almost half the alien taxa are annuals and the proportion of annuals generally decreases with altitude; in the alpine zone only 24% are annuals (Fig. 2). Grasses make up 25% of the alien flora. The proportion of alien perennial grasses increases with altitude with almost 33% of alien taxa in the alpine zone being perennial grasses. The proportion of alien woody taxa is highest in montane forest. Most alien taxa are of European or Asian origin; the proportion of taxa with European or Asian is highest in treeless high altitude zones (Fig. 3). Taxa from other parts of the world are uncommon although South and Central American taxa make up at least 10% of species in the lowest zones. Of taxa with a recorded use, most have been used as ornamentals; the proportions of ornamental and human use alien taxa are greatest in mid elevations where there is human habitation and historic timber plantations; the proportion of taxa used for agricultural purposes generally increases with altitude (Fig. 4). The best represented families in the alien flora are Poaceae (63 taxa), Asteraceae (39 taxa), Fabaceae (28 taxa), Caryophyllaceae (22 taxa), Rosaceae (19 taxa) and Brassicaceae (18 taxa).

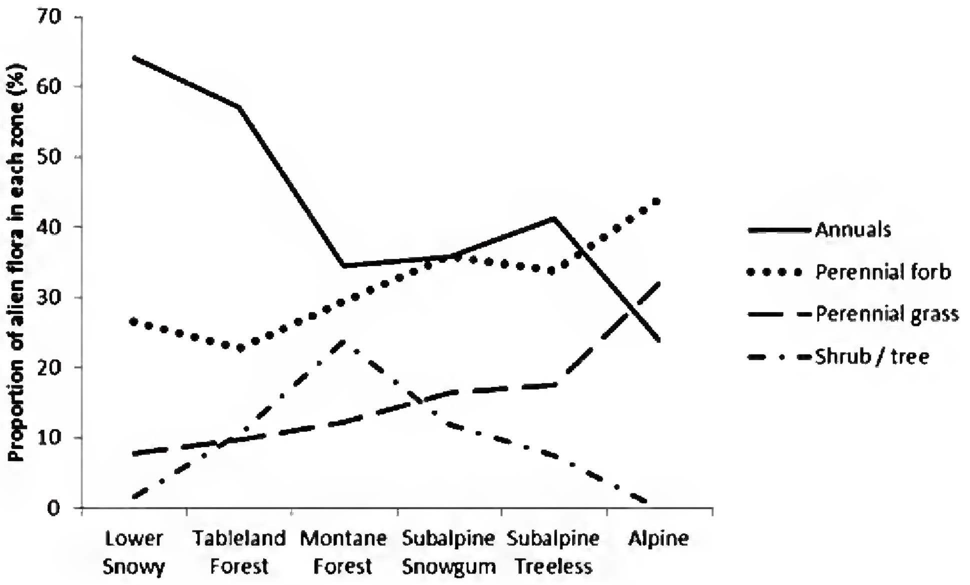


Fig. 2. Proportion of alien taxa in each zone by life form. The data are plotted as line graphs for ease of comparison between life forms and zones; zones are approximately correlated with altitude.

Table 8. Endemic, geographically restricted and threatened plant species in Kosciuszko National Park.

CE – Critically Endangered; E = Endangered; V = Vulnerable. EPBC = *Environmental Protection and Biodiversity Conservation Act 1999*; TSC = *Threatened Species Conservation Act 1995*

Taxon	**Common Name**	**Endemic To Knp**	**NSW Ocurrences Confined To Knp**	**Threat Status**
Abrotanella nivigena (F.Muell) F.Muell. ex Benth.	Snow-wort		√	
Aciphylla glacialis (F.Muell.) Benth	Mountain Celery		√	
Acrothamnus maccraei (F.Muell.) Quinn			√	
Agrostis joyceae S.W.L.Jacobs	Hair Bent		√	
Agrostis thompsoniae S.W.L.Jacobs	Alpine Bent		√	
Almaleea capitata (J.H.Willis) Crisp & P.H.Weston	Slender Parrot-pea		√	
Argyrotegium fordianum (M.Gray) J.M.Ward & Breitw.	Soft Cottonleaf		√	
Argyrotegium mackayi (Buchanon) J.M.Ward & Breitw.	Silver Cudweed		√	
Argyrotegium nitidulum (Hook.f.) J.M.Ward & Breitw.	Shining Cudweed		√	V (EPBC, TSC)
Asperula polymera I.Thomps.			√	
Astelia alpina var. *novae-hollandiae* Skottsb.	Pineapple Grass		√	
Astelia psychrocharis F.Muell.	Kosciuszko Pineapple Grass		√	
Astrotricha sp. Suggan Buggan (J. Turner 211) Vic. Herbarium			√	
Bertya findlayi F.Muell	Mountain Bertya		√	
Brachyscome sp. alpine herbfields (A.C.Beauglehole 40875) P.S.Short			√	
Brachyscome stolonifera G.L.R.Davis	Spreading Daisy	√		
Brachyscome tadgellii Tovey & P.Morris	Tadgell's Daisy		√	
Calotis glandulosa F.Muell.	Mauve Burr-Daisy			V (EPBC, TSC)
Calotis pubescens (F.Muell. ex Benth.) N.G.Walsh & K.L.McDougall	Max Mueller's Burr-daisy		√ Extant occurrences confined to KNP	E (TSC)
Carex archeri Boott	Archer's Carex		√	E (TSC)
Carex canescens L.	Short Sedge		√	
Carex hypandra F.Muell. ex Benth.	Alpine Fen-sedge		√	
Carex jackiana Boott	Carpet Sedge		√	
Carex raleighii Nelmes	Raleigh Sedge		(√) Bulk of NSW Occurrences in KNP	E (TSC)
Carpha alpina R.Br.	Small Flower-rush		√	
Carpha nivicola F.Muell.	Broad-leaf Flower-rush		√	
Chiloglottis cornuta Hook.f.	Green Bird Orchid		√	
Chionochloa frigida (Vickery) Conert	Robust Wallaby Grass	√		
Colobanthus affinins (Hook.) Hook.f.			√	
Colobanthus curtisiae J.G.West	Curtis' Colobanth		√	V (EPBC)
Colobanthus pulvinatus F.Muell.	Hard cushion-plant		√	
Coprosma niphophila Orchard		√		
Coprosma nivalis W.R.B.Oliver	Snow Coprosma		√	
Coprosma perpusilla Colenso subsp. *perpusilla*	Creeping Coprosma		√	
Correa lawrenceana Hook. var. *latrobeana* (F.Muell. ex Hannaford) Paul G.Wilson	Mountain Correa		√	
Craspedia alba J.Everett & Joy Thompson	White Billy-buttons		√	
Craspedia costiniana J.Everett & Joy Thompson		√		
Craspedia leucantha F.Muell.			√	
Craspedia maxgrayi J.Everett & Joy Thompson	Woolly Billy-buttons		√	
Cystopteris tasmanica Hook.	Brittle Bladder-fern		√	
Dichosciadium ranunculaceum (F.Muell. ex Hook.) Domin var. *ranunculaceum*		√		
Diplaspis nivis Van den Borre & Henwood	Snow Pennywort		√	
Discaria nitida Tortosa	Shining Anchor Plant		(√) Bulk of NSW Occurrences in KNP	V (TSC)
Diuris ochroma D.L.Jones	Pale Golden Moths			V (EPBC), E (TSC)
Drosera arcturi Hook.	Alpine Sundew		√	
Epacris glacialis (F.Muell.) M.Gray	Reddish Bog-heath		√	
Epilobium tasmanicum Hausskn.	Snow Willow-herb		√	
Erigeron conyzoides F. Muell.	Daisy Fleabane		√	
Erigeron setosus (Benth.) M.Gray		√		
Eucalyptus chapmaniana Cameron	Bogong Gum		√	
Eucalyptus saxatilis J.B.Kirkp. & Brooker	Suggan Buggan Mallee		√	E (TSC)
Euphrasia alsa F.Muell.	Dwarf Eye-bright	√		
Euphrasia collina subsp. *glacialis* (Wettst.) W.R.Barker		√		
Euphrasia collina subsp. *lapidosa* W.R.Barker		√		

Taxon	**Common Name**	**Endemic To Knp**	**NSW Ocurrences Confined To Knp**	**Threat Status**
Euphrasia scabra R.Br.				E (TSC) Presumed Extinct in KNP
Euphrasia sp. 3 (Ramshead Range) sensu W.R.Barker (1982)		√		
Ewartia nubigena (F.Muell.) Beauverd	Silver Ewartia		√	
Galium roddii Ehrend. & McGill.		√		
Genoplesium turfosum D.L.Jones			√	
Gentianella muelleriana subsp. *alpestris* (L.G.Adams) Glenny		√		
Gentianella polysperes (L.G.Adams) Glenny	Early Forest-gentian		√	
Gentianella sylvicola (L.G.Adams) Glenny	Late Forest-gentian		√	
Geranium sessiliflorum Cav.			√	
Gingidia algens (F.Muell.) J.W.Dawson		√		
Glycine latrobeana (Meisn.) Benth.	Clover Glycine		√	V (EPBC)
Haloragis milesiae Peter G. Wilson & Makinson		√		
Herpolirion novae-zelandiae Hook.f.	Sky Lily		√	
Hierochloe submutica F.Muell.	Alpine Holy-grass		√	
Hovea sp. aff. *heterophylla* sensu McDougall & Walsh (2007)		√		
Irenepharsus magicus Hewson	Elusive Cress		√	E (TSC)
Juncus antarcticus Hook.f.	Cushion Rush		√	
Kelleria dieffenbachii (Hook.) Endl.			√	
Leucochrysum albicans (A. Cunn.) subsp. *albicans* var. *tricolor* (DC.) Paul G. Wilson				E (EPBC)
Luzula acutifolia subsp. *nana* Edgar		√		
Muehlenbeckia diclina subsp. Gippsland (R.O.Makinson 1007)	Weeping Lignum		√	
Nematolepis ovatifolia (F.Muell.) Paul G.Wilson		√		
Olearia sp. Rhizomatica (I.R. Telford 11549)			√	
Olearia stenophylla N.G.Walsh	Happy Jacks Daisy Bush	√		
Oreomyrrhis brevipes Mathias & Constance	Branched Carraway		√	
Oreomyrrhis pulvinifica F.Muell.	Cushion Carraway		√	
Orites lancifolius F.Muell.	Alpine Orites		√	
Oschatzia cuneifolia (F. Muell.) Drude	Wedge Oschatzia		√	
Pelargonium helmsii Carolin	Alpine Stork's-bill		√	
Pentachondra pumila (Forster & Forster f.) R.Br.	Carpet Heath		√	
Phebalium glandulosum subsp. *riparium* R.L.Giles	Snowy River Phebalium		√	
Phebalium squamulosum subsp. *alpinum* (Benth.) Paul G.Wilson	Alpine Phebalium		√	
Pimelea alpina F.Muell. ex Meisn.	Alpine Rice Flower		√	
Pimelea axiflora subsp. *alpina* (Benth.) Threlfall	Alpine Bootlace-bush		√	
Plantago alpestris B.G.Briggs, Carolin & Pulley	Veined Plantain		√	
Plantago glacialis B.G.Briggs, Carolin & Pulley	Small Star Plantain		√	
Plantago muelleri Pilger	Star Plantain		√	
Poa orthoclada N.G.Walsh	Avon Tussock-grass		√	
Podolepis sp. N.E. Alps (N.G.Walsh 5964) Vic. Herbarium			√	
Pomaderris cotoneaster N.A.Wakef.	Cotoneaster Pomaderris			E (EPBC, TSC)
Pomaderris pallida N.A.Wakef.	Pale Pomaderris			V (EPBC, TSC)
Prasophyllum innubum D.L. Jones				CE (EPBC, TSC)
Prasophyllum retroflexum D.L.Jones	Congested Leek Orchid		√	V (TSC)
Psychrophila introloba (F.Muell.) W.A.Weber	Alpine Marsh-marigold		√	
Pterostylis crassicaulis (D.L.Jones) G.N.Backh.		√		
Pterostylis dubia R.Br			√	
Pterostylis oreophila Clemesha	Blue-tongue Greenhood			CE (EPBC), E (TSC)
Ranunculus acrophilus B.G.Briggs		√		
Ranunculus anemoneus F.Muell.	Anemone Buttercup	√		V (EPBC, TSC)
Ranunculus clivicola B.G.Briggs		√		
Ranunculus dissectifolius F.Muell. ex Benth.		√		
Ranunculus muelleri Benth.	Felted Buttercup		√	
Ranunculus niphophilus B.G.Briggs	Snow Buttercup	√		
Rutidosis leiolepis F.Muell.	Monaro Golden Daisy			V (EPBC, TSC)
Rytidosperma australe (Petrie) Clayton & Renvoize ex Connor & Edgar	Southern Sheep-grass		√	
Rytidosperma nivicola (Vickery) Connor & Edgar	Snow Wallaby-grass		√	
Rytidosperma pumilum (Kirk) Clayton & Renvoize ex Connor & Edgar	Feldmark Grass		√	V (EPBC, TSC)
Rytidosperma vickeryae M.Gray & H.P.Linder	Perisher Wallaby-grass	√		E (TSC)
Schizeilema fragoseum (F.Muell.) Domin	Alpine Pennywort		√	
Schoenus calyptratus Kuk.	Alpine Bog Rush		√	
Senecio longipilus I.Thomps.	Longhair Fireweed		√	
Stackhousia pulvinaris F.Muell.	Alpine Stackhousia		√	
Thesium australe R.Br.	Austral Toadflax			V (EPBC, TSC)

Taxon	**Common Name**	**Endemic To Knp**	**NSW Ocurrences Confined To Knp**	**Threat Status**
Trisetum spicatum subsp. *australiense* Hulten ex Veldkamp	Bristle Grass		√	
Uncinia compacta R.Br.	Compact Hook-sedge		√	
Uncinia sinclairii Boott			√	
Uncinia sulcata K.L.Wilson	Small Hook-sedge		√	
Veronica densifolia (F.Muell.) F.Muell.			√	
Veronica nivea Lindl.	Milfoil Speedwell		√	
Wahlenbergia densifolia Loth.	Fairy Bluebell		√	
Xerochrysum palustre (Flann) R.J.Bayer	Swamp Everlasting			V (EPBC)
	TOTALS	25	86	24

Table 9. Species at distributional limits, with disjunct occurrences, or uncommon in the Alps in Kosciuszko National Park.

Taxon	**Common Name**	**Conservation Significance**
Acacia brownii (Poiret) Steudel	Heath Wattle	Disjunct occurrence
Acacia dallachiana F.Muell.	Catkin Wattle	Northern and Eastern limit
Acacia deanei (R.Baker) Welch *et al.* subsp. *paucijuga* (F.Muell. ex N.A.Wakef.)Tind.	Green Wattle	Disjunct occurrence in lower Snowy River
Acacia doratoxylon A.Cunn.	Currawang	Disjunct occurrence in lower Snowy River
Acacia floribunda (Vent.) Willd.	White Sally Wattle	Disjunct occurrence in lower Snowy River
Astrotricha linearis A.Cunn. Ex Benth. *sens lat.*	Narrow-leaved Star-hair	Uncommon in the Alps
Australopyrum pectinatum (Labill.) A.Löve	Comb Wheat Grass	Uncommon in the Alps
Baeckea latifolia (Benth.) A.R.Bean	Subalpine Baeckea	Uncommon in the Alps
Banksia canei J.H.Willis	Mountain Banksia	Northern limit
Bertya riparia Halford & R.J.F.Hend		Uncommon in the Alps
Blechnum chambersii Tindale	Lance Water Fern	Uncommon in the Alps
Brachyscome obovata G.L.R.Davis	Baw Baw Daisy	Northern limit
Callitriche umbonata Hegelm.	Winged Water-starwort	Eastern limit
Callitris glaucophylla Joy Thompson & L. A. S. Johnson	White Cypress Pine	Disjunct occurrence in lower Snowy River
Calotis anthemoides F.Muell.	Cut-leaved Burr-daisy	Uncommon in the Alps
Cardamine gunnii Hewson	Lilac Bitter-cress	Uncommon in the Alps
Cassinia laevis R.Br.	Cough Bush	Disjunct occurrence
Cassinia monticola Orchard	Mountain Cassinia	Northern limit
Cassinia ochracea Orchard		Northern and Southern limit
Celmisia pugioniformis M.Gray & Given		Northern limit
Chenopodium desertorum (J.Black) J.Black subsp. *microphyllum* Paul G.Wilson		Disjunct occurrence in lower Snowy River
Chiloglottis turfosa D.L.Jones		Western limit
Convolvulus graminetinus R.W.Johnson	Grassland Bindweed	Uncommon in the Alps
Corysanthes hispida (D.L.Jones) D.L.Jones & M.A.Clem.	Bristly Helmet Orchid	Uncommon in the Alps
Craspedia coolaminica J.Everett & Joy Thompson		Northern limit
Cyphanthera albicans (A.Cunn.) Miers subsp. *albicans*	Grey Ray Flower	Disjunct occurrence in lower Snowy River
Deyeuxia affinis M.Gray	Allied Bent-grass	Northern limit
Deyeuxia microseta Vickery		Uncommon in the Alps
Dicksonia antarctica Labill.	Soft Tree Fern	Uncommon in the Alps
Dillwynia palustris Jobson & P.H.Weston		Uncommon in the Alps
Diuris subalpina D.L.Jones		Western limit
Drosera binata Labill.	Forked Sundew	Uncommon in the Alps
Elaeocarpus holopetalus F.Muell.	Black Oliveberry	Disjunct occurrence
Epacris celata Crowden	Cryptic Heath	Northern limit
Epacris impressa Labill.	Common Heath	Disjunct occurrence
Epacris robusta Benth.	Round-leaf Heath	Western limit
Eriochilus magenteus D.L.Jones		Southern and Western Limit
Eucalyptus albens Benth.	White Box	Disjunct occurrence in lower Snowy River
Eucalyptus camaldulensis Dehnh.	River Red Gum	Eastern edge of Distribution
Eucalyptus fastigata Deane & Maiden	Brown Barrel	Western limit
Eucalyptus lacrimans L.A.S.Johnson & K.Hill	Weeping Snow Gum	Northern, Southern and Western Limit
Eucalyptus ovata Labill.	Swamp Gum	Uncommon in the Alps

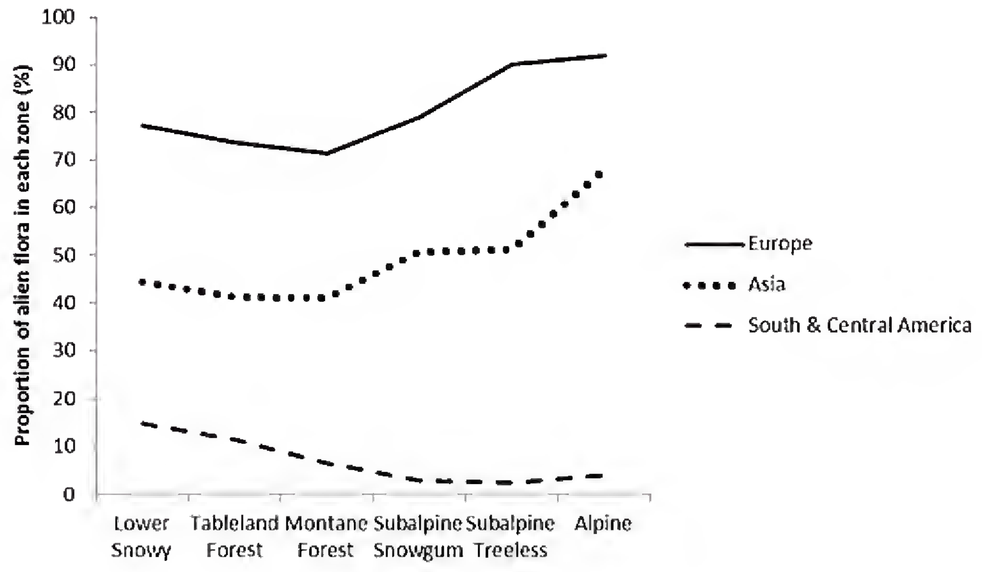
Taxon	**Common Name**	**Conservation Significance**
Eucalyptus rossii R.Baker & H.G.Sm.	Inland Scribbly Gum	Southern limit
Euryomyrtus denticulata (Maiden & Betche) Trudgen		Northern and Western Limit
Gingidia harveyana (F. Muell.) J. W.Dawson	Slender Gingidia	Northern limit
Gleichenia microphylla R.Br.	Scrambling Coral Fern	Uncommon in the Alps
Glossostigma diandrum (L.) Kuntze	Spoon-leaf Mud-mat	Southern limit
Glycine microphylla (Benth.) Tindale	Small-leaf Glycine	Uncommon in the Alps
Gompholobium minus Sm.	Dwarf Wedge Pea	Southern limit
Goodia lotifolia Salisb.	Golden Tip	Uncommon in the Alps
Grevillea parvula Molyneux & Stajsic	Genoa Grevillea	Uncommon in the Alps
Hakea eriantha R.Br.	Tree Hakea	Uncommon in the Alps
Hovea rosmarinifolia A.Cunn.	Mountain Beauty	Uncommon in the Alps
Huperzia australiana (Herter) Holub	Fir Clubmoss	Northern limit
Hybanthus vernonii (F.Muell.) F.Muell. subsp. *vernonii*	Erect Violet	Disjunct occurrence
Isolepis producta (C.B.Clarke) K.L.Wilson	Nutty Club-rush	Uncommon in the Alps
Leptospermum polygalifolium Salisb. subsp. *polygalifolium*	Tantoon Teatree	Western limit
Leucopogon gelidus (F.Muell. ex Benth.) N.A.Wakef.		Northern limit
Logania granitica A.J.Whalen & B.J.Conn		Western limit
Malva preissiana Miq.	Native Hollyhock	Disjunct occurrence
Mirbelia pungens A.Cunn. ex G.Don	Prickly Mirbelia	Uncommon in the Alps
Myriophyllum salsugineum Orchard	Lake Water-milfoil	Uncommon in NSW
Nicotiana suaveolens Lehm.	Native Tobacco	Disjunct occurrence in lower Snowy River
Notelaea ligustrina Vent.	Privet Mock-olive	Uncommon in the Alps
Olearia aglossa (Maiden & Betche) Lander	Alpine Daisy-bush	Northern limit
Oreomyrrhis argentea Hook.f.	Silver Carraway	Northern limit
Parsonsia brownii (Britten) Pichon	Mountain Silkpod	Uncommon in the Alps
Patersonia sericea var. *longifolia* (R.Br.) C.Moore & Betche	Purple Flag	Disjunct occurrence
Pelargonium rodneyanum Mitch. ex Lindl	Magenta Storksbill	Uncommon in the Alps
Persoonia confertiflora Benth.	Cluster-flower Geebung	Northern limit
Persoonia silvatica L.A.S.Johnson	Forest Geebung	Western limit
Pimelea bracteata Threlfall	Rice Flower	Eastern and Southern Limit
Pimelea curviflora var. *acuta* Threlfall		Western limit
Plantago antarctica Decne.	Mountain Plantain	Northern limit
Poa hookeri Vickery	Hooker's Tussock-grass	Northern limit
Poa petrophila Vickery	Rock Tussock-grass	Northern limit
Polystichum formosum Tind.	Broad Shield Fern	Uncommon in the Alps
Pomaderris lanigera (Andrews) Sims	Woolly Pomaderris	Uncommon in the Alps
Pomaderris ledifolia A.Cunn.	Sydney Pomaderris	Western limit
Prostanthera hirtula F.Muell. Ex. Benth.	Hairy Mintbush	Uncommon in the Alps
Pterostylis aneba D.L.Jones		Northern limit
Pterostylis foliata Hook.f.	Slender Greenhood	Northern limit
Pterostylis melagramma D.L.Jones		Northern limit
Pterostylis multiflora (D.L.Jones) G.N.Backh.		Southern and Western Limit
Pultenaea blakelyi Joy Thomps	Blakely's Bush-pea	Uncommon in the Alps
Pultenaea fasciculata Benth.	Bundled Bush Pea	Northern limit
Pultenaea microphylla Sieber ex DC.	Spreading Bush-pea	Disjunct and Near Southern Limit
Ranunculus diminutus B.G.Briggs	Brackish Plains Buttercup	Uncommon in the Alps
Ranunculus gunnianus Hook.	Gunns Alpine Buttercup	Northern and Eastern Limit
Rhytidosporum alpinum McGillivray		Southern and Western Limit
Ricinocarpos bowmanii F.Muell	Western Wedding Bush	Southern limit
Rytidosperma oreophilum H.P.Linder & N.G.Walsh	Mountain Wallaby-grass	Northern limit
Rytidosperma semiannulare (Labill.) Connor & Edgar	Tasmanian Wallaby-grass	Uncommon in the Alps
Rytidosperma setaceum (R.Br.) Connor & Edgar	Smallflower Wallaby-grass	Uncommon in the Alps
Salsola australis R.Br.	Russian Tumbleweed	Disjunct occurrence in lower Snowy River
Salsola tragus L. subsp. *tragus*	Slender Saltwort	Disjunct occurrence in lower Snowy River
Scleranthus singuliflorus (F.Muell.) Mattf.	Mossy Knawel	Northern limit
Senecio glabrescens (DC.) Sch. Bip.	Smooth Fireweed	Eastern limit
Solanum linearifolium Geras. ex Symon	Mountain Kangaroo Apple	Disjunct occurrence in lower Snowy River
Sphaerolobium vimineum Sm.	Leafless Globe-pea	Disjunct occurrence
Sticherus urceolatus M.Garrett & Kantvilas	Silky Fan Fern	Uncommon in the Alps
Tetratheca ericifolia Sm.	Pink Eye	Western limit
Tetratheca subaphylla Benth.	Leafless Pink-bells	Disjunct occurrence
Tetratheca thymifolia Sm.	Thyme Pink-bells	Disjunct occurrence
Vallisneria nana R.Br	Eel Grass	Southern limit

Table 10. Number of alien taxa in Kosciuszko National Park by each bioclimatic zone (excluding 35 taxa only known from cultivated plants).

	All Zones	Lower Snowy	Tableland Forest	Montane Forest	Subalpine Snowgum	Subalpine/Montane Treeless	Alpine
Total Taxa	**330**	**128**	**114**	**122**	**67**	**80**	**25**
Gymnosperms	14	0	0	12	2	0	0
Monocots	77	31	32	25	13	22	10
Dicots	239	97	82	85	52	58	15

Table 11. Invasive status of alien taxa in Kosciuszko National Park: Casual = apparently not persisting where found but may reinvade; Naturalised = persisting where found but currently largely confined to modified habitat; Invasive 1 = invades native habitat, currently known from < 5 locations; Invasive 2 = invades native habitat, known from > 5 locations, extent < 25% of Park; Invasive 3 = invades native habitat, known from > 5 locations, extent > 25% of Park; Invasive 4 = Invades native habitat; tends to be disruptive and dominate; Unknown = invasive status not known, however these taxa are rare so they are likely to be casual or naturalised. A location is defined for the purposes of this categorisation as being separated from another location by > 1 km. For the ratio, non-invasive includes the casual and naturalised categories.

Invasive status	**All zones**	**Lower Snowy**	**Tableland Forest**	**Montane Forest**	**Subalpine Snowgum**	**Subalpine / Montane plains**	**Alpine**
Unknown	79	28	15	9	13	5	0
Casual	13	3	6	7	1	0	2
Naturalised	110	37	45	54	20	20	8
Invasive 1	51	25	15	10	11	12	1
Invasive 2	54	24	19	25	11	26	7
Invasive 3	13	8	10	11	6	11	6
Invasive 4	10	3	4	6	5	6	1



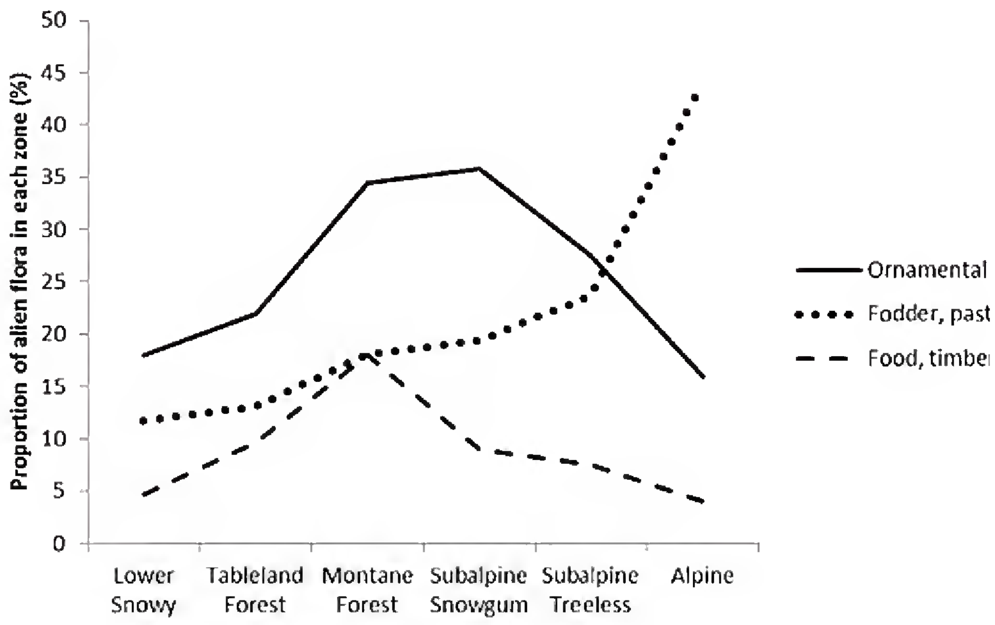


Fig. 3. Proportion of alien taxa in each zone by origin. There were very few taxa of North American and southern African origin in any zone so these are not shown. The data are plotted as line graphs for ease of comparison between life forms and zones; zones are approximately correlated with altitude.

Fig. 4. Proportion of alien taxa in each zone by use. The proportions of taxa with no known use are not shown. The data are plotted as line graphs for ease of comparison between life forms and zones; zones are approximately correlated with altitude.

Of the 330 non-cultivated alien taxa, 61% are casual or naturalised in the sense of Pyšek *et al.* (2004) (or of unknown invasive status and likely to be casual or naturalised) and more or less confined to disturbed habitat (Table 11). Of the taxa that do invade natural vegetation, only 9% (3% of total alien taxa) are commonly disruptive (i.e. rapidly spreading or highly competitive where established). Most alien taxa are infrequent. Of 56 alien taxa recorded in flora surveys prior to 2005, only six were recorded in more than 5% of plots (*Acetosella vulgaris* 43%, *Hypochaeris radicata* 27%, *Trifolium repens* 15%, *Taraxacum officinale* sens. lat. 9%, *Cerastium glomeratum* 8%, and *Cerastium vulgare* 7%) (McDougall *et al.* 2005).

Six native species (included in the Native Flora Summary section above) are known from highly modified habitat, especially road verges: *Ammobium alatum, Cynodon dactylon, Bothriochloa macra, Helichrysum luteoalbum, Leucochrysum albicans* subsp. *albicans* var. *tricolor, Lythrum hyssopifolia*. Although they are possibly non-native in Kosciuszko National Park, none is currently invasive. *Ammobium alatum* appears to be a casual, appearing regularly on the verges of Kosciuszko Road but not persisting. The status of *Helichrysum luteoalbum* and *Lythrum hyssopifolia* is unknown as they have been recorded rarely. *Leucochrysum albicans* var. *tricolor* is listed as endangered under the *EPBC Act 1999*. It has spread about 12 km into the park (to Connors Hill) along the Snowy Mountains Highway during the last decade. *Bothriochloa macra* appears to be spreading upwards along many roads and has reached 1400 m asl, an elevation far above its typical natural populations. As these species are naturally associated with disturbance, and as climate changes, they may be expected to further increase their distribution and abundance along disturbed edges. However, whether they should in future be regarded as potentially invasive species given their native status remains a challenging question for park managers.

Discussion

Native Flora

The large area and diverse habitats found within KNP mean that while the park occupies less than 1% of the area of NSW, it contains representations of nearly 25% of the State's native vascular plant taxa. This figure may ultimately increase with targeted sampling in future, as some areas of KNP are under-sampled compared to the alpine and subalpine zones.

Direct comparisons between protected areas are problematic given environmental and historical differences, but given the size of KNP and its representation of the State's flora, a brief comparison between KNP and another large temperate reserve complex in NSW, the Greater Blue Mountains World Heritage Area, is shown below. Interestingly, the number of native taxa per 10,000 hectares in KNP (16) is similar to that found in the Greater Blue Mountains World Heritage Area (15) even though the diversity of vegetation types found in GBMWHA is arguably greater e.g. there are almost twice the number of Myrtaceae and eucalypt taxa per 10,000 hectares in GBMWHA as compared to KNP (Table 12), with many more plant communities resulting. This similar species richness per unit area may be partially explained by the diversity of alpine and subalpine taxa in KNP balancing the diversity of Myrtaceae, Proteaceae and Fabaceae taxa found in the GBMWHA, but a more detailed comparison of taxa would need to be undertaken to further explore this relationship.

The majority of taxa in KNP are confined to only one or two floristic zones and the implications of this for future climate change need to be considered. A significant number of taxa (676) occur in the alpine and treeless areas and although not all of these species are confined to these floristic zones, all of the 25 endemic and many of the threatened taxa are. Additionally, 26 genera with their greatest diversity in cold climates have greater than 50% of their taxa in KNP. While taxa above the tree line are extremely limited in where they can move to if conditions change rapidly, taxa in treeless

Table 12. Comparison of areas and selected taxa groups between Kosciuszko National Park (KNP) and the Greater Blue Mountains World Heritage Area (GBMWHA).

Areas and Taxa Groups	KNP	GBMWHA
Area (ha)	690,660	1,032,649
% of NSW	0.86	1.3
Native taxa	1105	1500
Native taxa per 10,000 ha	16	15
Myrtaceae taxa	52	150
Myrtaceae taxa per 10,000 ha	0.75	1.45
Angophora/Corymbia/Eucalyptus taxa	31	91
Angophora/Corymbia/Eucalyptus taxa per 10,000 ha	0.45	0.88

areas at low to mid altitudes have far more potential to move environmentally, especially given the steep gradients found in KNP. The large size of KNP and the altitudinal and latitudinal range found within it will provide some measure of buffering against future change at these lower altitudes, but not at higher altitudes.

Families and genera with the largest number of taxa reflect the two primary environmental patterns found in KNP: the large tracts of eucalypt forest on the one hand, and the alpine and treeless zones on the other. The dicots are dominated by taxa in the Asteraceae, Fabaceae and Myrtaceae and the monocots by taxa in the Poaceae, Orchidaceae and Cyperaceae. *Eucalyptus* and *Acacia* are the most diverse dicot genera reflecting the treed vegetation; *Carex, Pterostylis* and *Rytidosperma* the most diverse monocot genera reflecting treeless vegetation and bogs. Most of the 86 species with their NSW distributions confined to KNP are species that otherwise occur in cold environments further south.

The location of KNP along the Great Dividing range and its location between the tablelands and slopes means that many southern Australian species (106) have their geographical distributions terminating somewhere in KNP. Many of these are northern limits of cooler climate species but there are also limital and disjunct occurrences of species that normally occur further west or else tablelands or near coastal species that have outlying populations on the east side of KNP.

Alien Flora

Considering the long and varied post-European land use in KNP – since the mid 1800s and including stock grazing, hydro-electricity construction and tourism – it is not surprising that a large number of alien taxa have been recorded (c. 26% of all alien taxa in NSW). In relation to reserve size, the alien flora of KNP is within the range of invasion of mountain protected areas globally (Kueffer *et al.* 2013). However, the number of alien taxa has increased greatly since the 1950s (Bear, Hill & Pickering 2006) and new alien taxa continue to be introduced. Much of the invasion pressure is probably associated with vehicles and road corridors. For instance, Mallen-Cooper (1990) germinated 27 species from soil collected in subalpine ski resort car parks that did not occur in the surrounding area. Twenty of these had not previously been recorded at such high elevation. Almost 30 years after this work was performed, only two of these species can be commonly found in the vicinity of these ski resorts (*Trifolium dubium* and *Trifolium glomeratum*). In a recent re-survey of permanent plots along road verges in KNP associated with a global monitoring program (Seipel *et al.* 2011), 32 alien taxa were recorded that had not been found in the same plots five years previously; 25 of these were new records for KNP (McDougall, Walsh and Wright, unpublished data). However, 14 alien taxa that had been recorded in 2006 / 07 were not located in the same plots in 2011 / 12. The roads and car parks of KNP are clearly testing grounds for new alien taxa. While there is considerable turnover of alien taxa in these disturbed areas and many taxa do not persist; the number that do persist across the large network of roads and trails is unknown. Monitoring of alien taxa along these entry vectors will be vital for identifying new alien species threats to the park. It should also enable park managers to identify movements of native taxa, which may also use these corridors. We have identified six New South Wales native species on road verges that are possibly non-native in Kosciuszko National Park.

The high number of alien taxa at mid-altitudes is probably a consequence of land use pressure and environmental filters. At these altitudes, historic agricultural pressures, tourism development and hydro-electricity construction have been greatest. Alien species richness tends to decline with altitude in mountains (Seipel *et al.* 2011). In the alpine zone at least, low temperature has probably limited invasion from highly invaded habitat below, where alien species which have been introduced are less likely to be alpine in their climatic preference. Therefore changes predicted in climate and snow cover (Hennessey *et al.* 2003) may make this environment more favourable to the establishment of exotic species.

Unlike the native flora of Kosciuszko National Park, which is predominantly perennial, the alien flora is almost equally annual and perennial. Most annuals are typically ruderals of European origin, which are effective colonisers of bare ground globally. In KNP, they are found mostly on road verges and disturbances associated with huts, ski resorts and hydro works. Alien species richness on these sites declines sharply within metres of the boundary with natural vegetation (Seipel *et al.* 2011), suggesting that most ruderals are not competitive with native taxa. The uses of the alien flora are consistent with their distribution within KNP. Ornamental taxa are more frequently found in mid-elevation vegetation zones, which have historically had garden plantings in ski resorts and hydro villages. Of taxa with a known use, perennial grasses used for fodder, pasture and erosion control dominate in the alpine zone. Woody alien species are most frequent in montane forest; many are conifers and were part of a plantation at Jounama near the Yarrangobilly River.

Five families comprising more than half the alien flora of KNP (Asteraceae, Brassicaceae, Caryophyllaceae, Fabaceae, Poaceae) also make up the majority of the alien flora in Australian temperate lowlands (McDougall *et al.* 2011) and globally (Daehler, 1998; Pyšek, 1998). The alien flora of a mountainous area such as KNP tends to be a subset of the surrounding lowland area suggesting that the upland alien flora is a product of ecological filtering of lowland alien flora (Alexander *et al.* 2011). Nonetheless, the KNP alien flora contains some species that are only found at high altitude in NSW (e.g. *Hieracium aurantiacum* and *Spiraea x billiardii*). Some have therefore bypassed the normal introduction pathway, probably escaping from gardens of Hydro settlements.

A small number of alien taxa are invasive and commonly disruptive in natural vegetation in KNP and, judging by their low frequency in available plot data, most are only locally abundant. There may therefore still be an opportunity to limit their spread but the park management resources being consumed by the worst of them limits investment in other management strategies (e.g. prevention). Based on our observations of rate of spread, competitive behaviour and area of suitable habitat, the most serious invasive taxa in KNP are *Anthoxanthum odoratum, Cytisus scoparius, Hieracium aurantiacum, Leucanthemum vulgare* and *Rubus spp*. Control programs are in place for all but *A. odoratum*. Strongly invasive taxa are disproportionately perennial. This is consistent with the findings of Godfree *et al.* (2004), who suggest that this indicates functional convergence with the native flora, which is predominantly perennial. Soil seed storage of long duration, effective dispersal strategies, rapid growth and allelopathic properties provide advantage to many of these taxa over native taxa.

Strongly invasive taxa should be of special concern in subalpine / montane treeless plains. While this vegetation contains the highest number of such alien taxa it also has almost 40% of the native flora of KNP and almost half of its threatened flora. Despite this, only a small proportion of the subalpine / montane treeless plains area is currently infested. *Hieracium aurantiacum* and *Leucanthemum vulgare,* two of the most aggressively competitive species in that vegetation, are being controlled. Prevention of their spread will be vital for the future integrity of treeless plains. Given predictions of higher temperatures in the Alps associated with global warming (Hennessey *et al.* 2003), prevention of their movement into the alpine zone will be equally important.

Threats

The coincidence of high areas of plant diversity and plant conservation significance with areas of historical and current disturbance presents ongoing threats to the protection of plants and plant communities in KNP. Legacies of past grazing and burning activities and current impacts from hydroelectric development and ski tourism have created many disturbed areas, especially in the upper floristic zones. While many of the most impacted areas have been rehabilitated, there are still many areas in which exotic species require significant and ongoing control. Further, the overall grazing pressure from large numbers of feral herbivores including horses, deer, rabbits and pigs not only impacts directly on plant structure and plant populations, but also provides potential for the colonisation and further spread of the pool of alien plant species found in the park. Additionally, projected increases in temperature and decreases in rainfall for southern NSW (NSW Office of Environment and Heritage, 2011) will have both direct effects on plant communities such as favouring heathland over grassland communities (Pickering & Armstrong, 2003) and indirect effects via increases in fire frequency, potentially changing the structure and composition of large tracts of interval sensitive alpine ash communities (Bowman et al, 2014). Changes in rainfall and temperature may also favour the spread of pathogens such as *Phytophthora* and Myrtle Rust. While significant park resources are currently being invested in alien plant and feral animal control, increased monitoring will be required to effectively evaluate the impact of current containment strategies and to check for new outbreaks. Accurate monitoring of the extent, frequency and severity of planned and unplanned fire and how species respond to combinations of these factors will also be critical in managing the impact of changing fire regimes on the flora of KNP.

Conclusion

Despite Kosciuszko being the largest, and one of the oldest, National Parks in NSW, its flora has until now not been fully documented. An understandable focus on the conservation importance of alpine and treeless vegetation has masked the importance of the large tracts of montane and tableland forest communities and their associated floras. We hope that while the alpine and subalpine areas of Kosciuszko will still be studied with enthusiasm, there may in future be a wider appreciation of the large tracts of montane and tablelands plant communities within the park and a greater emphasis on systematic and targeted sampling to more fully document the flora contained within these vegetation types. In particular, the low to mid altitude areas including Byadbo Wilderness, Pilot Wilderness and forests on the western flanks all require further survey effort.

While only two species are possibly extinct in KNP, populations of endangered and vulnerable species and small populations of species at their distributional limits occur throughout the park and will need to be monitored and managed in relation to the ongoing impacts associated with resort development, feral herbivores, invasive plant species, pathogens and changing climate and fire regimes. It is well to remember that the emblematic anemone buttercup, *Ranunculus anemoneus*, now restricted to Kosciuszko National Park, has recovered well with management intervention and the removal of grazing, but once also occurred in Victoria, becoming extinct due to grazing practices:

> *“Let us examine the lowly forms which blossom on the edge of a small rivulet percolating through the dense sward of snow-grasses. There, irrigated by the melting snow, are some endemic Ranunculi, the lovely white-flowered* Caltha introloba, *and the yellow-flowered* Ranunculus Millani and R. Gunnianus*; while on the little flat below us, near the same watercourse, bloomed the luxuriant Anemoneous Ranunculus, or, as it is named,* Ranunculus anemoneus, *the veritable king among the Australian Ranunculi, its lovely white petals frequently attaining a length of two inches. It is to be regretted that this lovely plant is fast disappearing from the summits of our Victorian Mountains, owing to inroads made into the native vegetation by stock, as these Alpine areas become increasingly occupied from year to year.”* James Stirling, 1887. Notes on the Flora of Mt. Hotham. *Vic. Nat.* **4**: 72–78. (Original capitalisations retained).

As well as providing a floristic baseline and inventory for Kosciuszko National Park, it is hoped our list will assist in conservation planning and also form the basis for wider biogeographic comparisons of the flora with other large temperate reserves within and beyond Australia.

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Appendix 1. Plant species list sources other than herbarium specimens.

Additional records were obtained through published peer reviewed papers and from recent site data. For newly described species or for species where the taxonomy is still unclear, specialists were consulted including Mark Clements (Australian National Herbarium), Neville Walsh and Jeff Jeanes (National Herbarium of Victoria).

Code	**Source**
A	Dr. Mike Austin, CSIRO , Canberra plot data (1980s–1990s)
AC	Dr. Andrew Claridge, Wildlife Ecologist, NPWS, Office of Environment and Heritage
AD	Anne Duncan, Volunteer Botanist
Atlas	Atlas of NSW Wildlife
C	Clayton-Greene, K.A. & Wimbush, D.J. (1988) Acacia dry scrub communities in the Byadbo area of the Snowy Mountains. *Cunninghamia*, **2**, 9–24.
CO	Bob Coveny, formerly Botanical Collector, The Royal Botanic Gardens & Domain Trust, NSW Office of Environment and Heritage
CUR	Currango Homestead plant list
F	CRA (Comprehensive Regional Assessment) data (late 1990s) as part of Regional Forest Agreement process
G	Genevieve Wright, Flora Ecologist, NPWS, NSW Office of Environment and Heritage
J	National Parks & Wildlife Service NSW / Forestry Commission NSW. (1983) *Harvesting and Rehabilitation of Jounama Pine Plantation, Kosciusko National Park – Environmental Impact Statement.* NPWS/FC, Canberra.
JB	John Benson, formerly Senior Plant Ecologist, The Royal Botanic Gardens & Domain Trust, NSW Office of Environment and Heritage
K	Keith McDougall, NSW Office of Environment and Heritage
M	MIREN (Mountain Invasion Research Network)
MC	Mallen-Cooper, J. (1990) Introduced Plants in the High Altitude Environment of Kosciusko National Park, South Eastern Australia. Dept. of Biogeography and Geomorphology, RSPS, ANU, Canberra
MCL	Mark Clements, Research Scientist, Centre for Australian National Biodiversity Research, CSIRO, Canberra
MD	Michael Doherty, Plant Ecologist, CSIRO, Canberra
W	Waste Point Herbarium, Kosciuszko National Park

Appendix 2. Vascular Plant Species List for Kosciuszko National Park.

Table shows family and taxa listed under major groupings, with common name, distribution across floristic zones, legal conservation status (state and federal), lien status (see main text for explanation of codes) and source of record (see Appendix 1 for explanation of codes; H = Herbarium record).

Group / Family / Taxon	Common Name	Lower Snowy <700m	Tableland Forest 400–1000m	Montane Forest 1000m–1400m	Subalpine Snowgum 1400m–1800m	Subalpine / Montane Treeless <1800m	Alpine >1800m	Legal Status	Alien Status	Source
LYCOPSIDA (Clubmosses & Quillworts)										
ISOETACEAE										
Isoetes muelleri A.Braun	Quillwort					√				H
LYCOPODIACEAE										
Huperzia australiana (Herter) Holub	Fir Clubmoss					√	√			H
Lycopodium fastigiatum R.Br.	Mountain Clubmoss				√	√	√			H
FILICOPSIDA (Ferns)										
ASPLENIACEAE										
Asplenium bulbiferum G.Forst.	Mother Spleenwort			√						H
Asplenium flabellifolium Cav.	Necklace Fern	√	√	√		√	√			H
Asplenium trichomanes L.	Common Spleenwort			√	√					H
Pleurosorus rutifolius (R.Br.) Fee	Bristly Cloak Fern	√	√							H
BLECHNACEAE										
Blechnum chambersii Tindale	Lance Water Fern			√						H
Blechnum fluviatile (R.Br.) Lowe ex Salomon	Ray Water Fern			√						H
Blechnum minus (R.Br.) Ettingsh.	Soft Water Fern		√							H
Blechnum nudum (Labill.) Mett. ex Luerssen	Fishbone Water Fern		√	√						H
Blechnum pennamarina subsp. *alpina* (R.Br.) T.C.Chambers & P.A.Farrant	Alpine Water Fern			√	√	√	√			H
Blechnum wattsii Tindale	Hard Water Fern		√							M
DENNSTAEDTIACEAE										
Histiopteris incisa (Thunb.) Sm.	Bat's Wing Fern			√						H
Hypolepis glandulifera Brownsey & Chinnock	Downy Ground Fern		√							M
Pteridium esculentum (G.Forst.) Cockayne	Bracken	√	√	√						M
DICKSONIACEAE										

Group / Family / Taxon	Common Name	Lower Snowy <700m	Tableland Forest 400–1000m	Montane Forest 1000m–1400m	Subalpine Snowgum 1400m–1800m	Subalpine / Montane Treeless <1800m	Alpine >1800m	Legal Status	Alien Status	Source
Calochlaena dubia (R.Br.) M.D.Turner & R.A.White	Rainbow Fern		√							H
Dicksonia antarctica Labill.	Soft Treefern		√	√						H
DRYOPTERIDACEAE										
Polystichum formosum Tind.	Broad Shield Fern	√		√						J
Polystichum proliferum (R.Br.) Presl	Mother Shield Fern		√	√	√	√	√			H
GLEICHENIACEAE										
Gleichenia dicarpa R.Br.	Coral Fern			√						H
Gleichenia microphylla R.Br.	Scrambling Coral Fern			√						H
Sticherus urceolatus M.Garrett & Kantvilas	Silky Fan Fern			√						H
HYMENOPHYLLACEAE										
Hymenophyllum peltatum (Poiret) Desv.	Alpine Filmy Fern				√					H
OPHIOGLOSSACEAE										
Botrychium australe R.Br.	Parsley Fern					√				H
Botrychium lunaria (L.) Sw.	Moonwort					√				H
Ophioglossum lusitanicum L. subsp. *coriaceum* (A.Cunn.) Clausen	Adder's Tongue					√				H
POLYPODIACEAE										
Grammitis poeppigiana (Mett.) Pic. Serm.	Alpine Finger-fern						√			H
PTERIDACEAE										
Adiantum aethiopicum L.	Common Maidenhair		√							M
Cheilanthes austrotenuifolia Quirk & Chambers	Rock Fern	√	√							H
Cheilanthes distans (R.Br.) Mett.	Bristly Cloak Fern	√	√							H
Cheilanthes sieberi Kunze subsp. *sieberi* (R.Br.) Mett.	Poison Rock Fern	√	√							H
Pellaea falcata (R.Br.) Fee	Sickle Fern	√								H
Pteris tremula R.Br.	Tender Brake		√							M
WOODSIACEAE										
Cystopteris tasmanica Hook.	Brittle Bladder-fern					√	√			H
CONIFEROPSIDA (Conifers)										
CUPRESSACEAE										
Callitris endlicheri (Parl.) Bailey	Black Cypress Pine	√	√							H
Callitris glaucophylla Joy Thompson & L. A. S. Johnson	White Cypress Pine	√	√							H
* *Calocedrus decurrens* (Torrey) Florin	Incense Cedar			√					Nat	J
* *Cupressus nootkatensis* D.Don	Nootka Cypress			√					Nat	J
* *Cupressus sempervirens* L.	Italian Cypress				√				Cult	T
* *Hesperocyparis glabra* (Sudw.) Bartel	Mexican Cypress				√				Cult	T

PINACEAE									
* *Abies concolor* (Gord.) Hildebrand	Colorado / White Fir				√			Cult	T
* *Cedrus deodara* (Roxb. ex D.Don) G.Don	Deodar Cedar				√			Cult	T
* *Larix kaempferi* (Lamb.) Carr.	Japanese Larch			√				Nat	J
* *Picea abies* (L.) H.Karst.	Norway Spruce				√			Cult	T
* *Pinus banksiana* Lamb.	Jack Pine			√				Nat	J
* *Pinus contorta* Dougl.	Beach / Shore Pine				√			Inv1	H
* *Pinus densiflora* Sieb. & Zucc.	Japanese Red Pine			√				Nat	J
* *Pinus jeffreyi* Murr.	Jeffrey's Pine			√				Nat	J
* *Pinus lambertiana* Dougl.	Sugar Pine			√				Nat	J
* *Pinus monticola* Dougl. ex D.Don	Western White Pine			√				Nat	J
* *Pinus mugo* Turra	Mountain Pine				√			Nat	CUR
* *Pinus nigra* Arnold var. *nigra*	Austrian Pine			√				Nat	J
* *Pinus ponderosa* Dougl.	Western Yellow Pine			√				Nat	J
* *Pinus strobus* L.	Weymouth Pine			√				Nat	J
* *Pinus sylvestris* L.	Scots Pine			√				Nat	J
PODOCARPACEAE									
Podocarpus lawrencei Hook.f.	Mountain Plum Pine			√	√	√	√		H
MAGNOLIOPSIDA (Flowering Plants)									
Dicotyledons									
ACERACEAE									
* *Acer negundo* L.	Box Elder				√			Cult	T
* *Acer pseudoplatanus* L.	Sycamore Maple				√			Cult	T
ALISMATACEAE									
* *Alisma lanceolatum* With.	Narrow-leaved Water Plantain	√						Inv1	H
AMARANTHACEAE									
Alternanthera denticulata R.Br.	Lesser Joyweed	√							W
* *Alternanthera pungens* Kunth	Khaki Weed	√						Cas	H
APIACEAE									
Aciphylla glacialis (F.Muell.) Benth	Mountain Celery						√		H
Aciphylla simplicifolia (F.Muell.) Benth.	Mountain Aciphyll				√	√	√		H
* *Conium maculatum* L.	Hemlock	√		√	√			Inv1	H
Daucus glochidiatus (Labill.) Fischer, C.Meyer & Ave-Lall.	Native Carrot	√	√	√					H
Dichosciadium ranunculaceum (F.Muell. ex Hook.) Domin var *ranunculaceum*							√		H
Diplaspis nivis Van den Borre & Henwood	Snow Pennywort					√	√		H
Gingidia algens (F.Muell.) J.W.Dawson					√		√		H
Gingidia harveyana (F. Muell.) J. W.Dawson	Slender Gingidia				√	√			H
Lilaeopsis polyantha (Gand.) H.Eichler	Lilaeopsis					√			H
Oreomyrrhis argentea Hook.f.	Silver Carraway					√			H
Oreomyrrhis brevipes Mathias & Constance	Branched Carraway						√		H
Oreomyrrhis ciliata Hook.f.	Bog Carraway			√	√	√	√		H
Oreomyrrhis eriopoda (DC.) Hook.f.	Australian Carraway		√	√	√	√	√		H
Oreomyrrhis pulvinifica F.Muell.	Cushion Carraway						√		H
Oschatzia cuneifolia (F. Muell.) Drude	Wedge Oschatzia				√	√	√		H

Group / Family / Taxon	Common Name	Lower Snowy <700m	Tableland Forest 400–1000m	Montane Forest 1000m–1400m	Subalpine Snowgum 1400m–1800m	Subalpine / Montane Treeless <1800m	Alpine >1800m	Legal Status	Alien Status	Source
* *Pastinaca sativa* L. subsp. *sativa*	Parsnip					√			Inv1	H
Platysace lanceolata (Labill.) Druce	Shrubby Platysace	√	√	√						H
Schizeilema fragoseum (F.Muell.) Domin	Alpine Pennywort						√			H
Trachymene composita (Domin) B.L.Burtt				√	√					H
Trachymene humilis (Hook.f.) Benth. subsp. *humilis*	Alpine Trachymene					√				H
APOCYNACEAE										
Parsonsia brownii (Britten) Pichon	Mountain Silkpod			√						MD
* *Vinca minor* L.	Lesser Periwinkle				√				Cult	T
* *Vinca major* L.	Blue Periwinkle	√			√				Cult.	H
AQUIFOLIACEAE										
* *Ilex aquifolium* L.	English Holly				√				Cult	T
ARALIACEAE										
Astrotricha ledifolia DC	Common Star-hair			√						H
Astrotricha linearis A.Cunn. Ex Benth. *sens lat.*	Narrow-leaved Star-hair				√					H
Astrotricha asperifolia F.Muell. ex Klatt			√							H
Astrotricha sp. Suggan Buggan (J. Turner 211) Vic. Herbarium			√							W
* *Hedera helix* L.	English Ivy				√				Cult	T
Hydrocotyle algida N.A.Wakef.	Pennywort			√	√	√				H
Hydrocotyle hirta A.Rich. ex R.Br.	Hairy Pennywort			√						H
Hydrocotyle laxiflora DC.	Stinking Pennywort	√	√	√						H
Hydrocotyle sibthorpioides Lam.			√	√	√	√				H
Hydrocotyle tripartita R.Br. ex A.Rich.	Pennywort					√				H
Polyscias sambucifolia (Sieber ex DC.) Harms *sens lat.*	Elderberry Panax		√	√	√					H
ASTERACEAE										
Abrotanella nivigena (F.Muell) F.Muell. ex Benth.	Snow-wort						√			H
* *Achillea distans* Willd.	Tansyleaf Milfoil			√					Nat	H
* *Achillea millefolium* L.	Yarrow			√	√	√	√		Inv2	H
Ammobium alatum R.Br.	Winged Everlasting	√		√	√				NN	H
* *Anthemis arvensis* L.	Corn Chamomile			√					Unknown	H
* *Anthemis tinctoria* L.	Yellow Chamomile				√				Cult	T
Argyrotegium fordianum (M.Gray) J.M.Ward & Breitw.	Soft Cottonleaf				√	√	√			H
Argyrotegium mackayi (Buchanon) J.M.Ward & Breitw.	Silver Cudweed						√			H
Argyrotegium nitidulum (Hook.f.) J.M.Ward & Breitw.	Shining Cudweed					√	√	V (TSC)		H
Argyrotegium poliochlorum (N.G.Walsh) J.M.Ward & Brietw.	Grey-green Cudweed					√	√			H

Arrhenechthites mixtus (A.Rich) Belcher	Purple Groundsel			√						M
* *Artemisia absinthium* L.	Wormwood				√				Cult	T
* *Aster subulatus* Michx.	Wild Aster	√							Inv1	H
Bedfordia arborescens Hochr.	Blanket Leaf		√	√						H
Brachyscome aculeata (Labill.) Less.	Hill Daisy		√	√	√	√				H
Brachyscome decipiens Hook.f.	Field Daisy			√	√	√				H
Brachyscome diversifolia var. *diversifolia* (Graham) Fischer & Meyer	Large-headed Daisy		√	√						H
Brachyscome graminea (Labill.) F.Muell	Grass Daisy		√							H
Brachyscome nivalis F.Muell.	Snow Daisy						√			H
Brachyscome obovata G.L.R.Davis	Baw Baw Daisy				√	√	√			H
Brachyscome petrophila G.L.Davis	Rock Daisy		√	√						J
Brachyscome radicans Steetz ex Lehm.	Marsh Daisy					√				H
Brachyscome rigidula (DC.) G.L.R.Davis	Hairy Cut-leaf Daisy					√				H
Brachyscome scapigera (Sieber ex Sprengel) DC.	Tufted Daisy				√	√	√			H
Brachyscome spathulata Gaudich.			√	√	√	√	√			H
Brachyscome sp. alpine herbfields (A.C.Beauglehole 40875) P.S.Short							√			H
Brachyscome sp. leafy scapes (M.Gray & C.Totterdell 6632) P.S.Short					√		√			H
Brachyscome stolonifera G.L.R.Davis	Spreading Daisy					√	√			H
Brachyscome tadgellii Tovey & P.Morris	Tadgell's Daisy					√	√			H
Brachyscome tenuiscapa Hook.f. var. *pubescens* (Benth.) G.L.R.Davis	Mountain Daisy					√	√			H
Brachyscome willisii P.S.Short	Stiff Daisy		√							H
Calotis anthemoides F.Muell.	Cut-leaved Burr-daisy			√						H
Calotis glandulosa F.Muell.	Mauve Burr-daisy					√		V (TSC)		H
Calotis lappulacea Benth.	Yellow Burr-daisy	√								H
Calotis pubescens (F.Muell. ex Benth.) N.G.Walsh & K.L.McDougall	Max Mueller's Burr-daisy					√		E (TSC)		H
Calotis scabiosifolia Sonder & F.Muell. var. *integrifolia* F.Muell. ex Benth.	Rough Burr-daisy			√	√					H
* *Carduus nutans* L.	Nodding Thistle			√		√			Inv2	H
* *Carduus pycnocephalus* L.	Slender Thistle	√				√			Inv1	Atlas
* *Carduus tenuiflorus* Curtis	Winged Slender Thistle	√	√	√					Inv2	H
* *Carthamus lanatus* L.	Saffron Thistle	√							Inv1	J
Cassinia aculeata (Labill.) R.Br.	Dolly Bush	√	√	√						H
Cassinia laevis R.Br.	Cough Bush			√						H
Cassinia longifolia R.Br.	Cauliflower Bush	√	√	√						H
Cassinia monticola Orchard	Mountain Cassinia		√	√		√				H
Cassinia ochracea Orchard					√					H
Cassinia venusta Orchard	Elegant Cassinia		√							H
Celmisia costiniana M.Gray & Given	Carpet Snow Daisy				√	√	√			H
Celmisia pugioniformis M.Gray & Given					√	√	√			H
Celmisia sp. Pulchella (M.Gray & C.Totterdell 7079) Australian National Herbarium						√				H
Celmisia tomentella M.Gray & Given	Silver Snow Daisy					√	√			H
* *Centaurea melitensis* L.	Maltese Cockspur Thistle	√							Unknown	H
* *Centaurea solstitialis* L.	St Barnabys Thistle	√							Inv1	H
Centipeda cunninghamii (DC.) A.Braun & Asch.	Common Sneezeweed	√	√							H
Centipeda elatinoides (Less.) Benth. & Hook.f. ex O.Hoffm.				√						H
Centipeda minima (L.) A.Braun & Asch.	Spreading Sneezeweed	√		√						M
* *Chondrilla juncea* L.	Skeleton Weed	√	√	√			√		Inv2	H

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Chrysocephalum apiculatum (Labill.) Steetz	Common Everlasting	√	√	√		√				H
Chrysocephalum semipapposum (Labill.) Steetz	Clustered Everlasting	√	√	√	√	√				H
* *Cichorium intybus* L.	Chicory		√						Cas	MC
* *Cirsium arvense* (L.) Scop.	Perennial Thistle				√	√			Unknown	H
* *Cirsium vulgare* (Savi) Ten.	Spear Thistle	√	√	√	√	√			Inv3	H
* *Conyza bonariensis* (L.) Cronq.	Flaxleaf Fleabane	√	√			√			Unknown	MC
* *Conyza sumatrensis* (Retz.) E.Walker	Fleabane		√	√	√				Inv2	H
Coronidium gunnianum (Hook.) N.G. Walsh	Button Everlasting				√					H
Coronidium monticola N.G. Walsh	Button Everlasting			√	√	√	√			H
Coronidium scorpioides (Labill.) Paul G.Wilson	Button Everlasting		√	√						H
Coronidium waddelliae (J.H.Willis) Paul G. Wilson	Branched Everlasting		√	√	√					H
Cotula alpina (Hook.f.) Hook.f.	Alpine Cotula			√	√	√	√			H
Cotula australis (Sieber ex Sprengel) Hook f.	Common Cotula		√							H
* *Cotula coronopifolia* L.	Water Buttons	√							Unknown	W
Craspedia adenophora K.L.McDougall & N.G.Walsh	Sticky Billy-buttons						√			H
Craspedia alba J.Everett & Joy Thompson	White Billy-buttons					√	√			H
Craspedia aurantia J.Everett & Joy Thompson var. *aurantia*	Orange Billy-buttons				√	√	√			H
Craspedia aurantia var. *jamesii* (J.Everett & Joy Thompson) Schmidt-Leb	Green Billy-buttons		√	√	√	√	√			H
Craspedia canens J.Everett & Doust	Grey Billy-buttons			√	√					H
Craspedia coolaminica J.Everett & Joy Thompson						√				H
Craspedia costiniana J.Everett & Joy Thompson							√			H
Craspedia crocata J.Everett & Joy Thompson	Crimson Billy-buttons					√				H
Craspedia lamicola J.Everett & Joy Thompson	Bog Billy-buttons				√	√	√			H
Craspedia leucantha F.Muell.							√			H
Craspedia maxgrayi J.Everett & Joy Thompson	Woolly Billy-buttons						√			H
Craspedia paludicola Everett & Doust	Swamp Billy-buttons			√						H
Craspedia variabilis J.Everett & Doust	Bachelors Buttons		√	√						H
* *Crepis capillaris* (L.) Wallr.	Smooth Hawksbeard		√	√	√	√			Inv3	H
* *Crepis foetida* L. subsp. *foetida*	Stinking Hawksbeard				√				Unknown	H
Cymbonotus lawsonianus Gaudich	Bears-ear	√	√	√						H
Cymbonotus preissianus Steetz	Austral Bear's Ear	√	√	√		√				H
* *Dittrichia graveolens* (L.)	Stinkwort		√						Nat	M
Erigeron bellidioides (Hook.f.) S.J.Forbes & D.I.Morris	Violet Fleabane				√	√	√			H
Erigeron conyzoides F. Muell.	Daisy Fleabane				√	√				H
Erigeron nitidus S.J.Forbes	Sticky Fleabane				√	√	√			H
Erigeron paludicola S.J.Forbes	Bog Fleabane					√	√			H
Erigeron setosus (Benth.) M.Gray							√			H

Euchiton involucratus (G. Forst.) Holub	Common Cudweed			√		√				H
Euchiton japonicus (Thunb.) Holub			√	√	√	√				H
Euchiton limosus (Drury) Holub						√	√			H
Euchiton sphaericus (Willd.) Holub	Star Cudweed	√	√							H
Euchiton traversii (Hook.f.) Holub	Mat Cudweed				√	√				H
Euchiton umbricola (J.H.Willis) Anderb	Cliff Cudweed						√			H
Ewartia nubigena (F.Muell.) Beauverd	Silver Ewartia						√			H
* *Gamochaeta calviceps* (Fernald) Cabrera	Cudweed	√							Inv1	H
* *Gamochaeta purpurea* (L.) Cabrera	Purple Cudweed		√						Nat	M
* *Hieracium aurantiacum* subsp. *carpathicola* Nägeli & Peter	Orange Hawkweed				√	√			Inv4	H
Helichrysum leucopsideum DC.	Satin Everlasting			√						W
Helichrysum luteoalbum (L.) Rchb.	Jersey Cudweed		√	√	√					H
* *Hypochaeris glabra* L.	Smooth Catsear	√	√	√					Nat	H
* *Hypochaeris radicata* L.	Catsear	√	√	√	√	√	√		Inv3	H
* *Lactuca serriola* L.	Prickly Lettuce	√				√			Inv2	H
Lagenophora montana Hook.f.					√	√	√			H
Lagenophora stipitata (Labill.) Druce	Blue Bottle-daisy		√	√		√				H
Leptinella filicula (Hook.f.) Hook.f. ex Benth.	Mountain Cotula			√						H
Leptorhynchos elongatus DC.	Lanky Buttons					√				H
Leptorhynchos squamatus subsp. *alpinus* Flann	Scaly Buttons			√	√	√	√			H
Leptorhynchos squamatus (Labill.) Less. subsp. *squamatus*						√				H
* *Leucanthemum* x *superbum* (Bergmans ex J.W.Ingram) D.H.Kent	Shasta Daisy				√				Unknown	H
* *Leucanthemum vulgare* Lam.	Oxeye Daisy	√		√	√	√			Inv4	H
Leucochrysum albicans (A.Cunn.) subsp. *albicans* var. *albicans* Paul G.Wilson				√						H
Leucochrysum albicans (A.Cunn.) subsp. *albicans* var. *tricolor* (DC.) Paul G.Wilson	Hoary Sunray			√	√			E (EPBC)	NN	H
Leucochrysum alpinum (F.Muell.) R.J.Dennis & N.G.Walsh	Alpine Sunray					√	√			H
* *Matricaria matricarioides* (Less.) Porter	Rounded Chamomille				√				Nat	
Olearia aglossa (Maiden & Betche) Lander	Alpine Daisy-bush			√	√					H
Olearia algida N.A.Wakef.	Alpine Daisy-bush				√	√	√			H
Olearia alpicola (F.Muell.) Benth.	Alpine Daisy Bush			√	√					H
Olearia argophylla (Labill.) F. Muell. ex Benth.	Native Musk		√							H
Olearia brevipedunculata N.G.Walsh	Rusty Daisy-bush				√	√	√			H
Olearia erubescens (Sieber ex DC.) Dippel	Pink-tip Daisy Bush		√	√	√					H
Olearia floribunda (Hook.f.) Benth.	Heath Daisy Bush			√	√					H
Olearia glandulosa (Labill.) Benth.	Swamp Daisy Bush			√						H
Olearia iodochroa (F.Muell.) F.Muell. ex Benth.	Violet Daisy Bush		√			√				H
Olearia lasiophylla Lander				√	√					H
Olearia lirata (Sims) Hutch.	Snowy Daisy Bush		√							H
Olearia megalophylla (F.Muell.) F.Muell. ex Benth.	Large-leaf Daisy Bush			√	√					H
Olearia myrsinoides (Labill.) F.Muell. ex Benth.	Blush Daisy Bush					√				H
Olearia phlogopappa subsp. *flavescens* (Hutch.) Messina	Dusty Daisy Bush			√	√	√	√			H
Olearia phlogopappa subsp. *serrata* Messina	Dusty Daisy Bush			√	√	√	√			H
Olearia ramulosa (Labill.) Benth.	Twiggy Daisy Bush			√						H
Olearia sp. *Rhizomatica* (I.R. Telford 11549)					√	√				H
Olearia rosmarinifolia (DC.) Benth.			√							H
Olearia stellulata (Labill.) DC.	Snow Daisy Bush		√	√						H

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Olearia stenophylla N.G.Walsh	Happy Jacks Daisy Bush			√						H
Olearia tenuifolia (DC.) Benth.	Thin-leaf Daisy Bush		√							W
* *Onopordum acanthium* L.	Scotch Thistle	√			√				Unknown	H
Ozothamnus alpinus (N.A.Wakef.) Anderberg	Alpine Everlasting				√	√	√			H
Ozothamnus conditus (N.A.Wakef.) Anderberg	Pepper Everlasting	√	√							H
Ozothamnus cupressoides Puttock & D.J.Ohlsen	Kerosene Bush				√	√	√			H
Ozothamnus ferrugineus (Labill.) Sweet	Tree Everlasting		√							H
Ozothamnus obcordatus subsp. *major* (Benth.) P.S.Short	Grey Everlasting	√								H
Ozothamnus secundiflorus (N.A.Wakef.) C.Jeffrey	Cascade Everlasting			√	√	√	√			H
Ozothamnus stirlingii (F.Muell.) Anderberg	Ovens Everlasting			√	√					H
Ozothamnus thyrsoideus DC.	Sticky Everlasting		√	√	√					H
Parantennaria uniceps (F.Muell.) Beauverd	Parantennaria					√	√			H
Picris angustifolia subsp. *merxmuelleri* Lack & Holzapfel				√	√	√	√			H
Podolepis hieracioides F.Muell.	Long Podolepis					√				H
Podolepis jaceoides (Sims) Voss	Showy Copper-wire Daisy					√				H
Podolepis robusta (Maiden & Betche) J.H.Willis	Mountain Lettuce				√	√	√			H
Podolepis sp. N.E. Alps (N.G.Walsh 5964) Vic. Herbarium						√				H
Rhodanthe anthemoides (Sprengel) Paul G.Wilson	Chamomile Sunray					√	√			H
Rutidosis leiolepis F.Muell.	Monaro Golden Daisy					√		V (TSC)		H
Senecio bathurstianus (DC.) Sch. Bip.		√		√						H
Senecio campylocarpus I.Thomps.	Bulging Fireweed					√				H
Senecio diaschides D.G.Drury	Erect Groundsel	√	√	√						H
Senecio distalilobatus I.Thomps.	Distal-lobe Fireweed		√		√	√				H
Senecio extensus I.Thomps.	Subalpine fireweed					√				H
Senecio glabrescens (DC.) Sch. Bip.	Smooth Fireweed					√				H
Senecio gunnii (Hook.f.) Belcher	Mountains Fireweed			√	√	√	√			H
Senecio hispidulus A.Rich.	Hill Fireweed	√	√							H
Senecio lageniformis I.Thomps.	Monaro Fireweed					√				H
Senecio linearifolius var. *arachnoideus* I.Thomps.	Cobweb Fireweed Groundsel			√	√					H
Senecio linearifolius var. *denticulatus* I.Thomps.	Fireweed Groundsel			√	√					H
Senecio linearifolius var. *latifolius* I.Thomps.	Broadleaf Fireweed Groundsel			√	√					H
Senecio longipilus I.Thomps.	Longhair Fireweed			√		√				H
Senecio microbasis I.Thomps.	Narrow Fireweed	√								H
Senecio minimus Poir.	Toothed Fireweed		√	√						H
Senecio nigrapicus I.Thomps	Black-tip Fireweed					√				H
Senecio niveoplanus I.Thomps	Snowplain Fireweed				√					J
Senecio pectinatus var. *major* F.Muell. Ex Belcher	Alpine Groundsel						√			H

Senecio phelleus I.Thomps.	Rock Fireweed		√	√						H
Senecio pinnatifolius var. *alpinus* (Ali) I.Thomps.	Variable Groundsel		√	√	√	√	√			H
Senecio pinnatifolius A.Rich. var. *pinnatifolius*	Variable Groundsel			√	√	√				H
Senecio prenanthoides A.Rich.	Common Fireweed		√	√	√					H
Senecio quadridentatus Labill.	Cotton Fireweed	√	√	√						H
Senecio vagus subsp. *vagus* F.Muell.	Saw Groundsel			√						H
Senecio velleioides A.Cunn. ex DC.	Forest Groundsel					√	√			H
Sigesbeckia australiensis D.L.Schulz	Cobber Weed	√								H
Sigesbeckia orientalis L. subsp. *orientalis*	Indian Weed	√	√							F
* *Silybum marianum* (L.) Gaertner	Variegated Thistle	√							Unknown	MC
Solenogyne gunnii (Hook.f.) Cabrera		√	√	√		√				H
* *Sonchus asper* (L.) Hill	Prickly Sowthistle	√	√						Inv2	H
* *Sonchus oleraceus* L.	Common Sowthistle	√	√	√					Inv2	H
* *Tagetes minuta* L.	Stinking Roger	√							Inv1	H
* *Tanacetum parthenium* (L.) Schultz-Bip.	Feverfew				√				Inv1	H
Taraxacum aristum Hagl. & Markl.	Mountain Dandelion					√				H
* *Taraxacum officinale* Weber spp. aggr.	Dandelion	√		√	√	√	√		Inv3	H
* *Tolpis barbata* (L.) Gaertn.	Yellow Hawkweed		√						Nat	H
* *Tragopogon dubius* Scop.	Goatsbeard					√			Inv2	H
Vittadinia cuneata DC.	Fuzzweed	√	√			√				H
Vittadinia gracilis (Hook.f.) N.T.Burb.	Woolly New Holland Daisy	√								J
Vittadinia muelleri N.T.Burb.	Narrow Leaf New Holland Daisy	√	√							F
Vittadinia sulcata N.T.Burb.	Furrowed New Holland Daisy	√								H
Vittadinia tenuissima (Benth.) J.M.Black	Western New Holland Daisy	√								H
* *Xanthium strumarium* L.	Noogoora Burr	√							Inv1	H
Xerochrysum bracteatum (Vent.) Tzvelev	Golden Everlasting			√						H
Xerochrysum palustre (Flann) R.J.Bayer	Swamp Everlasting					√		V (TSC)		H
Xerochrysum subundulatum (Sch. Bip.) R.J.Bayer	Alpine Everlasting			√	√	√				H
Xerochrysum viscosum (DC.) R.J.Bayer	Sticky Everlasting	√	√			√				H
ATHEROSPERMATACEAE										
Atherosperma moschatum Labill.	Southern Sassafras			√						H
BERBERIDACEAE										
* *Berberis aquifolium* Pursh	Oregon Grape			√					Nat	H
* *Berberis vulgaris* L.	Common Barberry			√					Nat	H
BETULACEAE										
* *Betula pendula* Roth	Silver Birch				√				Cult	T
BIGNONIACEAE										
Pandorea pandorana (Andrews) Steenis	Wonga Wonga Vine	√	√							H
BORAGINACEAE										
* *Amsinckia calycina* (Moris) Chater		√							Unknown	H
* *Amsinckia intermedia* Fischer & C.Meyer	Common Fiddleneck		√						Unknown	MC
* *Anchusa arvensis* (L.) Bieb.	Wild Bugloss	√			√				Unknown	H
Cynoglossum australe R.Br.		√	√	√						H
Cynoglossum suaveolens R.Br.	Sweet Hound's Tongue	√	√	√						H
* *Echium plantagineum* L.	Paterson's Curse	√	√						Inv2	M

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* *Echium vulgare* L.	Vipers Bugloss	√				√			Inv2	H
* *Heliotropium amplexicaule* Vahl	Blue Heliotrope	√							Inv2	H
Myosotis australis R.Br.	Australian Forget-me-not					√				H
* *Myosotis discolor* Pers.	Forget-me-not			√		√			Inv2	H
Myosotis exarrhena F.Muell.	Sweet Forget-me-not		√	√	√	√				H
* *Myosotis laxa* subsp. *caespitosa* (Schultz) Hyl. ex Nordh.	Water Forget-me-not	√				√			Inv4	H
* *Myosotis sylvatica* Hoffm.	Forget-me-not				√				Cult	T
* *Symphytum officinale* L. subsp. *officinale*	Comfrey					√			Nat	K
BRASSICACEAE										
Barbarea grayi Hewson	Native Wintercress					√	√			H
* *Barbarea intermedia* Boreau					√	√			Nat	H
* *Barbarea verna* (Miller) Asch.	Wintercress					√			Nat	H
* *Brassica rapa* L. subsp. *campestris* (L.) A. R.Chapman	Turnip								Unknown	MC
* *Capsella bursa-pastoris* (L.) Medikus	Shepherds Purse			√			√		Nat	H
Cardamine astoniae I.Thomps.	Spreading Bitter-cress				√	√	√			H
Cardamine franklinensis I.Thomps.	Franklin Bitter-cress					√				H
Cardamine gunnii Hewson	Lilac Bitter-cress					√				H
* *Cardamine hirsuta* L.	Common Bitter-cress	√							Unknown	H
Cardamine lilacina Hook.	Lilac Bitter-cress		√			√	√			H
Cardamine papillata I.Thomps.	Forest Bitter-cress					√				H
Cardamine paucijuga Turcz.	Annual Bitter-cress		√	√						H
Cardamine robusta I.Thomps.							√			H
* *Diplotaxis tenuifolia* (L.) DC.	Sand Rocket								Unknown	MC
Drabastrum alpestre (F.Muell.) O.Schulz	Mountain Cress					√				H
* *Erophila verna* (L.) Chevall. subsp. *verna*	Whitlow Grass				√	√			Inv3	H
* *Hirschfeldia incana* (L.) Lagr.-Fossat	Hairy Brassica	√			√	√			Nat	H
Irenepharsus magicus Hewson	Elusive Cress			√				E (TSC)		H
* *Lepidium africanum* (Burm.f.) DC.	Common Peppercress	√							Inv1	L
* *Lepidium bonariense* L.	Argentine Peppercress			√					Cas	M
* *Lepidium campestre* (L.) W.T.Aiton	Field Cress			√		√			Nat	H
* *Lepidium perfoliatum* L.									Unknown	MC
* *Raphanus raphanistrum* L.	Wild Radish								Unknown	W
Rorippa dictyosperma (Hook.) L.A.S.Johnson	Cress			√						H
Rorippa laciniata (F.Muell.) L.A.S.Johnson	Jagged Bitter-cress	√				√				H
* *Rorippa nasturtium-aquaticum* (L.) Hayek	Watercress	√							Unknown	W
* *Rorippa palustris* (L.) Besser	Yellow Cress	√				√			Inv1	H
* *Sisymbrium officinale* (L.) Scop.	Hedge Mustard								Unknown	MC

* *Sisymbrium orientale* L.	Indian Hedge Mustard								Unknown	W
* *Turritis glabra* L.	Tower Mustard				√	√			Nat	H
CAMPANULACEAE										
* *Campanula rapunculoides* L.					√				Nat	H
Isotoma axillaris Lindl.	Rock Isotome	√								H
Lobelia gibbosa Labill.	Tall Lobelia		√	√						H
Lobelia pedunculata R.Br.	Matted Pratia		√	√		√				H
Lobelia simplicicaulis R.Br.				√						H
Lobelia surrepens Hook.f.	Mud Pratia					√	√			H
Wahlenbergia ceracea Loth.	Waxy Bluebell			√	√	√	√			H
Wahlenbergia communis Carolin	Tufted Bluebell	√	√							W
Wahlenbergia densifolia Loth.	Fairy Bluebell					√				H
Wahlenbergia gloriosa Loth.	Royal Bluebell			√	√	√	√			H
Wahlenbergia gracilenta Loth.	Annual Bluebell	√	√							F
Wahlenbergia gracilis (G.Forst.) A.DC.	Sprawling Bluebell	√	√			√				H
Wahlenbergia graniticola Carolin	Granite Bluebell		√							J
Wahlenbergia littoricola P.J.Sm.			√							J
Wahlenbergia multicaulis Benth.	Tadgell's Bluebell					√				H
Wahlenbergia planiflora subsp. *planiflora* P.J.Sm.	Flat Bluebell			√						H
Wahlenbergia stricta subsp. *stricta* (R.Br.) Sweet	Tall Bluebell	√	√	√						H
CAPRIFOLIACEAE										
* *Centranthus ruber* (L.) DC. subsp. *ruber*	Red Valerian								Unknown	MC
* *Dipsacus fullonum* L.	Wild Teazle	√	√	√					Cas	H
* *Lonicera japonica* Thunb.	Japanese Honey-suckle		√						Inv1	M
* *Scabiosa atropurpurea* L.	Pincushion				√				Cult	T
* *Symphoricarpos albus* var. *laevigatus* (Fernald) S.F.Blake	Snowberry			√					Nat	H
CARYOPHYLLACEAE										
* *Arenaria leptoclados* (Reichb.) Guss.	Lesser Thyme-leaved Sandwort	√							Unknown	H
* *Arenaria serpyllifolia* L.	Thyme-leaved Sandwort	√					√		Nat	H
* *Cerastium balearicum* Herm.	Lesser Mouse-ear Chickweed	√							Unknown	MC
* *Cerastium glomeratum* Thuill.	Mouse-ear Chickweed	√	√	√	√	√	√		Inv3	H
* *Cerastium tomentosum* L.					√	√			Nat	K
* *Cerastium vulgare* Hartm.	Mouse-ear Chickweed		√	√		√	√		Inv3	H
Colobanthus affinis (Hook.) Hook.f.						√	√			H
Colobanthus curtisiae J.G.West	Curtis' Colobanth					√		V (EPBC)		H
Colobanthus nivicola M.Gray	Soft Cushion-plant						√			H
Colobanthus pulvinatus F.Muell.	Hard Cushion-plant						√			H
* *Dianthus armeria* L.	Deptford Pink			√	√	√			Inv2	H
* *Dianthus barbatus* L.	Sweet William				√				Cult	H
Gypsophila tubulosa (Jaub. & Spach) Boiss.	Annual Chalkwort	√	√	√						F
* *Lychnis coronaria* (L.) Desr.	Rose Campion		√	√					Inv1	H
* *Moenchia erecta* (L.) P.Gaertner, Meyer & Scherb.	Erect Chickweed		√						Unknown	MC
* *Paronychia brasiliana* DC.	Chilean Whitlow Wort	√							Inv2	H
* *Petrorhagia dubia* (Raf.) G.Lopez & Romo	Wild Pink		√						Unknown	H
* *Petrorhagia nanteuilii* (Burnat) P.Ball & Heyw.	Childling Pink	√	√			√			Inv1	H

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* *Polycarpon tetraphyllum* (L.) L.	Four-leaf Allseed	√	√	√					Nat	M
* *Sagina apetala* Ard.	Annual Pearlwort		√						Nat	H
Sagina namadgi L.G.Adams	Native Pearlwort					√				H
* *Saponaria officinalis* L.	Soapwort	√	√						Nat	H
Scleranthus biflorus (Forster & Forster f.) Hook.f.	Two-flowered Knawel		√	√	√	√	√			H
Scleranthus brockiei P.A.Will.	Brock Knawel				√		√			H
Scleranthus diander R.Br.	Tufted Knawel	√				√				H
Scleranthus fasciculatus (R.Br.) Hook.f.	Knawel	√	√	√		√				H
Scleranthus singuliflorus (F.Muell.) Mattf.	Mossy Knawel				√	√	√			H
* *Silene gallica* L.	Catchfly	√	√						Nat	H
* *Silene nocturna* L.	Mediterranean Catchfly								Unknown	MC
* *Silene vulgaris* (Moench) Garcke	Bladder Campion				√				Unknown	H
* *Spergula arvensis* L.	Corn Spurry				√				Inv1	
* *Spergularia rubra* (L.) J.S. & C.Presl.	Sandspurry						√		Inv1	H
Stellaria angustifolia Hook.	Swamp Starwort					√				H
Stellaria flaccida Hook.			√							H
* *Stellaria graminea* L.					√				Unknown	H
* *Stellaria media* (L.) Vill.	Common Chickweed			√					Nat	H
Stellaria multiflora Hook.	Many Flowered Starwort					√	√			H
Stellaria pungens Brongn.	Prickly Starwort	√	√	√	√	√	√			H
CASUARINACEAE										
Allocasuarina verticillata (Lam.) L.A.S.Johnson	Drooping Sheoak	√	√	√						H
CELASTRACEAE										
Stackhousia monogyna Labill.	Creamy Candles	√	√	√	√	√				H
Stackhousia pulvinaris F.Muell.	Alpine Stackhousia				√	√	√			H
Stackhousia viminea Sm.	Slender Stackhousia		√							H
CHENOPODIACEAE										
* *Chenopodium album* L.	Fat Hen			√					Cas	H
Chenopodium desertorum (J.Black) J.Black subsp. *microphyllum* Paul G.Wilson		√								H
* *Chenopodium detestans* Kirk					√	√			Inv1	J
Chenopodium erosum R.Br.	Papery Goosefoot					√	√			H
* *Chenopodium murale* L.	Nettle-leaf Goosefoot	√							Unknown	H
* *Chenopodium vulvaria* L.			√						Unknown	J
Dysphania pumilio (R.Br.) Mosyakin & Clemants	Small Crumbweed	√		√						H
Einadia hastata (R.Br.) A.J.Scott	Berry Saltbush	√								H
Einadia nutans (R.Br.) A.J.Scott subsp. *nutans*	Climbing Saltbush	√	√							H
Salsola australis R.Br.	Russian Tumbleweed	√								H

Salsola tragus L. subsp. *tragus*	Slender Saltwort	√							H
CONVOLVULACEAE									
Convolvulus angustissimus R.Br. subsp. *angustissimus*		√		√		√			H
Convolvulus graminetinus R.W.Johnson	Grassland Bindweed					√			H
Dichondra repens Forster & Forster f.	Kidney Weed	√	√	√	√	√			H
CRASSULACEAE									
Crassula helmsii (Kirk) Cockayne	Swamp Stonecrop	√			√	√			H
Crassula peduncularis (Sm.) F	Purple Crassula				√	√			H
Crassula sieberiana (Schultes & Schultes f.) Druce	Australian Stonecrop	√				√	√		H
Crassula tetramera (Toelken) A.P.Druce & Sykes					√	√			H
* *Sedum acre* L.	Bitter Stonecrop	√	√			√		Inv2	H
* *Sedum album* L.		√		√	√			Nat	H
* *Sedum rupestre* L.					√			Cult	H
DILLENIACEAE									
Hibbertia obtusifolia DC.	Hoary Guinea Flower		√	√	√				H
Hibbertia pedunculata R.Br. ex DC.	Heart-leaved Hibbertia		√						H
Hibbertia serpyllifolia DC.	Hairy Guinea Flower	√							W
DROSERACEAE									
Drosera arcturi Hook.	Alpine Sundew					√	√		H
Drosera auriculata Backh. ex Planchon	Sundew		√						M
Drosera binata Labill.	Forked Sundew		√						G
Drosera hookeri R.P. Gibson, B.J. Conn & Conran			√						H
Drosera peltata Thunb.	Pale Sundew			√	√	√			H
ELAEOCARPACEAE									
Elaeocarpus holopetalus F.Muell.	Black Oliveberry			√					MD
ELATINACEAE									
Elatine gratioloides A.Cunn.	Waterwort				√	√			H
ERICACEAE									
Acrothamnus hookeri (Sond.) Quinn			√	√	√	√			H
Acrothamnus maccraei (F.Muell.) Quinn				√	√		√		H
Acrothamnus montanus (R.Br.) Quinn	Snow Beard-heath				√	√	√		H
Acrotriche divaricata R.Br.	Tall Acrotriche			√					H
Acrotriche serrulata (Labill.) R. Br.	Honeypots		√	√					H
Astroloma humifusum (Cav.) R. Br.	Native Cranberry	√	√	√					H
Brachyloma daphnoides (Sm.) Benth.	Daphne Heath	√	√	√					H
* *Calluna vulgaris* (L.) Hull	Heather				√			Cult	T
Epacris breviflora Stapf	Drumstick Heath			√		√			H
Epacris celata Crowden	Cryptic Heath					√	√		H
Epacris glacialis (F.Muell.) M.Gray	Reddish Bog-heath				√	√	√		H
Epacris gunnii Hook.f.				√	√	√	√		H
Epacris impressa Labill	Common Heath		√						AD
Epacris paludosa R.Br.	Swamp Heath			√	√	√	√		H
Epacris petrophila Hook.f.	Snow Heath					√	√		H
Epacris robusta Benth.	Round-leaf Heath			√					H

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Gaultheria appressa A.W.Hill	White Waxberry			√						H
Leucopogon attenuatus A.Cunn.	Grey Beard-heath	√	√	√						H
Leucopogon ericoides (Sm.) R. Br.	Pink Beard-heath	√	√							H
Leucopogon fletcheri Maiden & Betche subsp. *brevisepalus* J.M.Powell	Twin Flower Beard-heath		√	√						H
Leucopogon fraseri A.Cunn.						√				H
Leucopogon gelidus (F.Muell. ex Benth.) N.A.Wakef.			√	√	√					H
Leucopogon microphyllus (Cav.) R. Br. var. *pilibundus* (Cunn. ex DC.) Benth.	Hairy Beard-Heath		√							W
Leucopogon virgatus (Labill.) R.Br.	Common Beard-heath		√							H
Lissanthe strigosa (Smith) R.Br.	Peach Heath	√	√							H
Melichrus urceolatus R.Br.	Urn Heath	√	√							H
Monotoca scoparia (Sm.) R.Br.	Broom Heath		√	√						H
Pentachondra pumila (Forster & Forster f.) R.Br.	Carpet Heath				√	√	√			H
Richea continentis B.L.Burtt	Candle Heath				√	√	√			H
EUPHORBIACEAE										
Adriana tomentosa Gaudich. var. *tomentosa*	Mallee Bitterbush	√								H
Bertya findlayi F.Muell	Mountain Bertya	√	√							H
Bertya oleifolia Planch.			√			√				H
Bertya riparia Halford & R.J.F.Hend			√							H
Bertya tasmanica subsp. *vestita* Halford & R.J.F.Hend	Mitchell Bertya (Fine-haired Variant)					√				H
Beyeria viscosa (Labill.) Miq.	Sticky Wallaby Bush	√								G
Euphorbia drummondii Boiss.	Balsam		√							M
* *Euphorbia lathyris* L.	Caper Spurge	√							Inv2	H
* *Euphorbia maculata* L.	Eyebane		√	√					Nat	M
* *Euphorbia peplus* L.	Petty Spurge	√							Inv1	H
Micrantheum hexandrum Hook.f.	Box Micrantheum		√	√						H
Poranthera microphylla Brongn.	Small Poranthera		√	√	√					H
Poranthera oreophila Halford & R.J.F.Hend.	Mountain Poranthera					√	√			H
Ricinocarpos bowmanii F.Muell	Western Wedding Bush		√	√						H
FABACEAE										
Subfamily Caesalpinioideae										
* *Gleditsia triacanthos* L.	Honey Locust								Unknown	MC
Senna aciphylla (Benth.) Randell	Sprawling Cassia	√								H
Subfamily Faboideae										
Almaleea capitata (J.H.Willis) Crisp & P.H.Weston	Slender Parrot-pea				√					H
Almaleea subumbellata (Hook.) Crisp & P.H.Weston				√						J
Bossiaea buxifolia A.Cunn.	Matted Bossiaea	√	√							H

Bossiaea distichoclada F.Muell.			√	√					H
Bossiaea foliosa A.Cunn.	Leafy Bossiaea		√						H
Bossiaea obcordata (Vent.) Druce	Spiny Bossiaea			√					H
Bossiaea riparia A.Cunn. ex Benth.	River Leafless Bossiaea					√			H
Bossiaea sericea I.Thomps.				√	√	√			H
Cullen microcephalum (Rchb. ex Hunze) J.W.Grimes	Mountain Psoralea		√	√					H
* *Cytisus scoparius* (L.) Link	English Broom		√	√	√			Inv4	H
Daviesia latifolia R.Br.	Hop Bitter-pea		√	√	√				H
Daviesia leptophylla A.Cunn. ex Don	Narrow-leaf Bitter-pea		√						H
Daviesia mimosoides R. Br. subsp. *acris* Crisp	Blunt-leaf Bitter-pea					√			H
Daviesia mimosoides R. Br. subsp. *mimosoides*	Blunt-leaf Bitter-pea			√	√				H
Daviesia ulicifolia subsp. *ruscifolia* Andrews	Gorse Bitter Pea		√	√	√	√			H
Desmodium brachypodum A.Gray	Large Tick-trefoil	√							H
Desmodium gunnii Benth. ex Hook.f.	Slender Tick-trefoil		√						M
Desmodium varians (Labill.) Endl.	Slender Tick-trefoil	√	√	√					H
Dillwynia palustris Jobson & P.H.Weston						√			H
Dillwynia phylicoides A.Cunn			√						H
Dillwynia prostrata Blakely	Matted Parrot Pea					√			H
Dillwynia sericea A.Cunn.	Showy Parrot Pea		√						H
* *Genista monspessulana* (L.) L.A.S.Johnson	Montpellier Broom			√				Nat	J
Glycine clandestina J.C.Wendl. species complex	Twining Glycine	√	√	√	√				H
Glycine latrobeana (Meisn.) Benth.	Clover Glycine					√			H
Glycine microphylla (Benth.) Tindale	Small-leaf Glycine		√						M
Glycine tabacina (Labill.) Benth.	Glycine Pea	√	√						H
Gompholobium huegelii Benth.	Pale Wedge Pea	√	√	√	√				H
Gompholobium minus Sm.	Dwarf Wedge Pea			√					H
Goodia lotifolia Salisb.	Golden Tip		√						W
Hardenbergia violacea (Schneev.) Stearn	False Sarsparilla	√	√	√					M
Hovea asperifolia I.Thomps. subsp. *asperifolia*				√	√				H
Hovea heterophylla A.Cunn. ex Hook.f.	Common Hovea					√			H
Hovea montana (Hook.f.) J.H.Ross	Mountain Purple Pea				√	√	√		H
Hovea rosmarinifolia A.Cunn.	Mountain Beauty		√						H
Hovea sp. aff. *heterophylla* sensu McDougall & Walsh (2007)						√			M
Indigofera adesmiifolia A.Gray	Tick Indigo		√						H
Indigofera australis Willd. subsp. *australis*	Austral Indigo	√							H
Indigofera australis Willd. Subsp. *hesperia* Peter G.Wilson & Rowe	Austral Indigo		√	√					H
Lespedeza juncea (L. f.) Pers. subsp. *sericea* (Thunb.) Steenis	Perennial Lespedeza	√	√						H
Lotus australis Andrews	Australian Trefoil		√	√					H
* *Lotus corniculatus* L.	Birds-foot Trefoil		√	√				Inv2	H
* *Lotus uliginosus* Schk.	Birds-foot Trefoil		√	√	√	√		Inv2	H
* *Lupinus polyphyllus* Lindl.	Russell Lupin			√		√		Inv1	H
* *Medicago arabica* (L.) Hudson	Spotted Burr Medic							Unknown	H
* *Medicago lupulina* L.	Black Medic	√		√				Nat	H
* *Medicago minima* (L.) Bartal.	Woolly Burr Medic	√						Unknown	J
* *Medicago polymorpha* L.	Burr Medic	√						Unknown	H
* *Medicago sativa* L.	Lucerne / Alfalfa	√			√			Unknown	H
* *Melilotus albus* Medikus	Bokhara		√	√	√		√	Inv1	H

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* *Melilotus indicus* (L.) All.	Hexham Scent	√							Inv1	J
Mirbelia oxylobioides F.Muell.		√	√	√		√				H
Mirbelia pungens A.Cunn. ex G.Don	Prickly Mirbelia	√								H
Oxylobium arborescens Aiton f.	Tall Shaggy Pea			√						H
Oxylobium ellipticum (Labill.) R.Br.	Common Shaggy Pea			√	√	√	√			H
Platylobium montanum I.Thomps.	Mountain Mirbelia		√	√						H
Podolobium alpestre (F.Muell.) Crisp & P.H.Weston	Alpine Shaggy Pea			√	√	√	√			H
Podolobium procumbens (F.Muell.) F.Muell. ex Crisp & P.H.Weston	Trailing Shaggy Pea		√							H
Pultenaea blakelyi Joy Thomps	Blakely's Bush-pea			√						H
Pultenaea capitellata Sieber ex DC.	Hard-head Bush-pea			√						H
Pultenaea fasciculata Benth.	Bundled Bush Pea		√	√		√				H
Pultenaea juniperina Labill.	Prickly Bush-pea		√	√	√					H
Pultenaea microphylla Sieber ex DC.	Spreading Bush-pea		√							W
Pultenaea polifolia A.Cunn.	Dusky Bush Pea					√				H
Pultenaea procumbens A.Cunn.	Heathy Bush-pea		√							H
Pultenaea setulosa Benth.	Stony Bush-pea		√							H
Pultenaea spinosa (DC.) H.B.Will	Spiny Bush-pea		√							H
Pultenaea subspicata Benth.	Low Bush-pea					√				H
Pultenaea vrolandii Maiden	Cupped Bush-pea		√							M
* *Robinia pseudoacacia* L.	Black Locust			√					Nat	MC
Sphaerolobium vimineum Sm.	Leafless Globe-pea					√				JB
Swainsona behriana F.Muell. ex J. Black	Behr's Swainson-pea				√	√				H
Swainsona monticola A.Cunn. ex Benth.	Notched Swainson-pea					√				M
* *Trifolium ambiguum* Bieb.	Kura Clover						√		Nat	H
* *Trifolium arvense* L.	Haresfoot Clover	√	√	√	√	√			Inv2	H
* *Trifolium campestre* Schreber	Hop Clover	√	√			√			Inv1	H
* *Trifolium cernuum* Brot.	Drooping-flowered Clover				√				Unknown	H
* *Trifolium dubium* Sibth.	Yellow Suckling Clover	√		√		√			Inv3	H
* *Trifolium glomeratum* L.	Clustered Clover	√	√						Inv2	M
* *Trifolium hirtum* All.	Rose Clover								Unknown	W
* *Trifolium hybridum* L.	Alsike Clover				√	√			Unknown	H
* *Trifolium incarnatum* L.	Crimson Clover								Unknown	MC
* *Trifolium pratense* L.	Red Clover			√					Nat	H
* *Trifolium repens* L.	White Clover		√	√		√	√		Inv3	H
* *Trifolium striatum* L.	Knotted Clover		√						Inv1	J
* *Trifolium subterraneum* L.	Subterranean Clover								Unknown	W
* *Vicia villosa* Roth	Russian Vetch				√				Unknown	H

Subfamily Mimosoideae									
Acacia alpina F.Muell.	Alpine Wattle				√	√			H
Acacia amoena H.L.Wendl.	Boomerang Wattle	√							H
Acacia boormanii Maiden	Snowy River Wattle	√	√						H
Acacia brownii (Poiret) Steudel	Heath Wattle			√					J
Acacia buxifolia A.Cunn. subsp. *buxifolia*	Box-leaved Wattle			√					H
Acacia dallachiana F.Muell.	Catkin Wattle			√					H
Acacia dealbata subsp. *dealbata* Link	Silver Wattle	√	√	√					H
Acacia dealbata subsp. *subalpina* Tindale & Kodela	Silver Wattle			√	√				H
Acacia deanei (R.Baker) Welch *et al.* subsp. *paucijuga* (F.Muell. ex N.A.Wakef.)Tind.	Green Wattle	√	√						H
Acacia doratoxylon A.Cunn.	Currawang	√	√						H
Acacia falciformis DC.	Broad-leaved Hickory		√						C
Acacia floribunda (Vent.) Willd.	White Sally Wattle	√							H
Acacia gunnii Benth.	Ploughshare Wattle		√						H
Acacia implexa Benth.	Hickory Wattle	√	√						H
Acacia kettlewelliae Maiden	Buffalo Wattle		√	√					H
Acacia kybeanensis Maiden & Blakely	Kybean Wattle		√						H
Acacia leprosa var. graveolens Maslin & D.J.Murphy	Cinnamon Wattle			√					H
Acacia mearnsii De Wild.	Black Wattle	√	√	√					H
Acacia melanoxylon R.Br.	Blackwood	√	√	√	√				H
Acacia mucronata	Narrow-leaved Wattle	√							W
Acacia obliquinervia Tindale	Mountain Hickory		√	√	√				H
Acacia paradoxa DC.	Kangaroo Thorn		√						H
Acacia penninervis Sieber ex DC. Var. *penninervis*	Mountain Hickory			√					H
Acacia pravissima F.Muell	Wedge-leaved Wattle		√	√					H
Acacia pycnantha Benth.	Golden Wattle		√						H
Acacia rubida A.Cunn.	Red-leaved Wattle		√	√					H
Acacia siculiformis A.Cunn. ex Benth.	Dagger Wattle		√	√					H
Acacia silvestris Tindale	Bodalla Silver Wattle		√	√					H
Acacia terminalis sens. lat.	Sunshine Wattle	√	√						H
Acacia ulicifolia (Salisb.) Court	Prickly Moses		√						H
Acacia verniciflua A.Cunn.	Varnish Wattle		√						H
GENTIANACEAE									
* *Centaurium erythraea* Rafn.	Common Centaury	√	√	√				Inv3	H
* *Centaurium tenuiflorum* (Hoffm. & Link) Fritsch ex Janch.	Branched Centaury	√	√	√				Nat	H
* *Cicendia quadrangularis* (Domb. ex Lam.) Griseb.	Square Cicendia		√					Unknown	H
Gentianella muelleriana subsp. *alpestris* (L.G.Adams) Glenny					√	√	√		H
Gentianella polysperes (L.G.Adams) Glenny	Early Forest-gentian			√					H
Gentianella sylvicola (L.G.Adams) Glenny	Late Forest-gentian			√					H
Sebaea ovata (Labill.) R.Br.	Yellow Centaury	√		√					H
GERANIACEAE									
* *Erodium cicutarium* (L.) L'Her. ex Aiton	Common Storksbill	√						Nat	H
Erodium crinitum Carolin	Blue Storksbill	√	√						H
* *Erodium moschatum* (L.) L'Her. ex Aiton	Musky Crowfoot		√					Unknown	MC
Geranium antrorsum Carolin	Rosetted Crane's-bill			√	√	√	√		H

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Geranium brevicaule Hook.	Alpine Crane's-bill					√				H
Geranium gardneri de Lange	Rough Crane's-bill	√	√							H
Geranium homeanum Turcz	Rainforest Crane's-bill	√	√		√		√			H
* *Geranium molle* L. var molle	Cranesbill Geranium	√							Unknown	H
Geranium obtusisepalum Carolin	Kosciuszko Crane's-bill			√						H
Geranium potentilloides L'Her. ex DC. var. *abditum* Carolin	Soft Crane's-bill			√	√	√	√			H
Geranium potentilloides L'Her. ex DC. var. *potentilloides*			√	√		√	√			H
Geranium retrorsum L'Her. ex DC.	Common Crane's Bill		√	√	√					H
Geranium sessiliflorum Cav.					√	√	√			H
Geranium solanderi Carolin var. *solanderi*	Native Geranium	√	√	√	√					H
Geranium sp. 2 (Flora of Victoria)		√								
Geranium sp. Pale pink flowers (M.Gray 5847) Vic. Herbarium			√	√						M
Pelargonium australe Willd.	Native Stork's-bill		√	√	√	√				H
Pelargonium helmsii Carolin	Alpine Stork's-bill				√	√	√			H
Pelargonium inodorum Willd.	Kopata	√								W
Pelargonium rodneyanum Mitch. ex Lindl	Magenta Stork's-bill		√							H
GOODENIACEAE										
Goodenia hederacea Sm. subsp. *alpestris* (K.Krause) Carolin			√	√	√	√	√			H
Goodenia hederacea Sm. subsp. *hederacea*	Ivy Goodenia			√						H
Goodenia ovata Smith	Hop Goodenia	√	√							C
Goodenia pinnatifida Schltdl.	Cut-leaf Goodenia	√								H
Scaevola albida var. *albida* (Sm.) Druce				√	√					
Scaevola hookeri (Vriese) F.Muell. ex Hook.f.	Creeping Fan Flower					√				H
Velleia montana Hook.f.	Mountain Velleia					√				H
Velleia paradoxa R.Br.	Spur Velleia	√		√						H
GROSSULARIACEAE										
* *Ribes uva-crispa* L.	Gooseberry			√		√			Nat	K
HALORAGACEAE										
Gonocarpus micranthus Thunb. subsp. *micranthus*	Creeping Raspwort				√	√	√			H
Gonocarpus montanus (Hook.f.) Orch.	Mat Raspwort			√	√	√	√			H
Gonocarpus tetragynus Labill.	Common Raspwort	√	√	√	√					H
Haloragis heterophylla Brongn.	Rough Raspwort	√								JB
Haloragis milesiae Peter G. Wilson & Makinson				√						H
Haloragodendron baeuerlenii (F.Muell.) Orch.	Shrubby Raspwort	√								H
Myriophyllum alpinum Orch.	Alpine Water-milfoil					√				H
Myriophyllum lophatum Orch.	Crested Water-milfoil				√	√				H

Myriophyllum pedunculatum Hook.f. subsp. *pedunculatum*	Mat Water-milfoil					√	√		H
Myriophyllum salsugineum Orch.	Lake Water-milfoil					√			H
Myriophyllum variifolium Hook.f.	Varied Water-milfoil					√			H
HYDROCHARITACEAE									
* *Elodea canadensis* Michx.	Canadian Pondweed	√						Nat	H
Vallisneria nana R.Br	Eel Grass	√							H
HYPERICACEAE									
* *Hypericum androsaemum* L.	Tutsan		√	√				Inv1	H
* *Hypericum calycinum* L.	Aaron's Beard				√			Cult	T
Hypericum gramineum G.Forst.	Small St. John's Wort	√	√	√	√				M
Hypericum japonicum Thunb.	Matted St John's Wort	√		√		√			H
* *Hypericum perforatum* L.	St. John's Wort	√	√	√		√		Inv2	H
LAMIACEAE									
Ajuga australis R.Br. *sens lat.*	Austral Bugle	√	√	√	√	√			H
Lycopus australis R.Br.	Australian Gipsywort				√				H
* *Marrubium vulgare* L.	Horehound	√		√				Inv1	H
* *Melissa officinalis* L.	Lemon Balm			√				Unknown	H
Mentha australis R.Br.	River Mint					√			W
Mentha diemenica Spreng.	Slender Mint			√					H
Mentha laxiflora Benth.	Forest Mint		√	√					H
* *Mentha pulegium* L.	Pennyroyal		√					Inv1	W
Mentha satureioides R.Br.	Native Pennyroyal		√						H
* *Mentha spicata* L.	Spearmint					√		Unknown	H
* *Origanum vulgare* L.	Oregano				√			Cult	T
Plectranthus parviflorus Willd.	Cockspur Flower		√						H
Prostanthera cuneata Benth.	Alpine Mint-bush				√	√	√		H
Prostanthera decussata F.Muell.	Dense Mintbush		√						H
Prostanthera hirtula F.Muell. Ex. Benth.	Hairy Mintbush		√						H
Prostanthera lasianthos Labill.	Victorian Christmas Bush		√	√					H
Prostanthera monticola B.J.Conn.	Buffalo Mint-bush			√					H
Prostanthera phylicifolia F.Muell.	Spiked Mint-bush	√		√					H
Prostanthera rotundifolia R.Br.	Round-leaved Mint-bush	√	√						H
* *Prunella vulgaris* L.	Self-heal		√	√				Inv3	H
* *Salvia verbenaca* L.	Wild Sage	√	√	√				Nat	H
Scutellaria humilis R.Br.	Dwarf Skullcap	√	√						H
* *Stachys byzantina* K.Koch	Woolly Stachys				√			Cult	T
Teucrium corymbosum R.Br.	Forest Germander			√		√			H
Westringia eremicola A.Cunn. ex Benth.	Slender Westringia			√					H
Westringia lucida B.Boivin	Shining Westringia				√	√			H
LAURACEAE									
Cassytha melantha R.Br.	Coarse Dodder-laurel		√						H
Cassytha pubescens R.Br.	Devil's Twine		√						H
LENTIBULARIACEAE									
Utricularia dichotoma Labill.	Fairy Aprons					√	√		H
Utricularia monanthos Hook.f.	Tasmanian Bladderwort					√	√		H

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LINACEAE										
Linum marginale A.Cunn.	Native Flax			√	√	√				H
LOGANIACEAE										
Logania albiflora (Andrews) Druce	Narrow leaf Logania			√						H
Logania granitica A.J. Whalen & B.J. Conn			√	√						H
Mitrasacme serpyllifolia R.Br.	Thyme Mitrewort					√				H
LORANTHACEAE										
Amyema miquelii (Lehm. ex Miq.) Tiegh.	Box Mistletoe	√	√							H
Amyema miraculosa subsp. *boormanii* (Blakely) Barlow	Fleshy Mistletoe		√							M
Amyema pendula (Sieber ex Streng.) Tiegh. subsp. *pendulum*	Drooping Mistletoe	√	√							H
Amyema quandang (Lindley) Tiegh. var. *quandang*	Grey Mistletoe	√	√							H
LYTHRACEAE										
Lythrum hyssopifolia L.	Hyssop Loosestrife	√		√						M
Lythrum salicaria L.	Purple Loosestrife			√						H
MALVACEAE										
Brachychiton populneus (Schott & Endl.) R.Br.	Kurrajong	√	√							H
Gynatrix pulchella (Willd.) Alef.	Hempbush		√							H
* *Malva neglecta* Wallr.	Dwarf Mallow			√	√				Unknown	H
* *Malva nicaeensis* All.	Mallow of Nice			√					Unknown	W
* *Malva parviflora* L.	Small-flowered Mallow		√						Nat	M
Malva preissiana Miq.	Native Hollyhock	√								H
* *Modiola caroliniana* (L.) G.Don	Red-flowered Mallow	√	√	√					Nat	H
Sida corrugata Lindl.	Corrugated Sida	√								H
* *Tilia platyphyllos* Scop.	Broad-leaved Lime				√				Cult	T
MENYANTHACEAE										
Nymphoides montana Aston	Marshwort			√	√	√				H
MONIMIACEAE										
Hedycarya angustifolia A.Cunn.	Native Mulberry		√							H
MORACEAE										
* *Ficus carica* L.	Fig		√						Inv1	M
MYRTACEAE										
Baeckea gunniana Schauer	Alpine Baeckea			√	√	√	√			H
Baeckea latifolia (Benth.) A.R.Bean	Subalpine Baeckea				√	√				H
Baeckea utilis F.Muell ex Miq.	Mountain Baeckea			√	√	√	√			H
Callistemon pallidus (Bonpl.) DC.	Lemon Bottlebrush			√						H

Callistemon pityoides F.Muell.	Alpine Bottlebrush			√	√	√			H
Callistemon sieberi DC.	River Bottlebrush	√							H
Calytrix tetragona Labill.	Common Fringe-myrtle		√						H
Eucalyptus albens Benth.	White Box	√	√						H
Eucalyptus blakelyi Maiden	Blakely's Red Gum		√						M
Eucalyptus bridgesiana R.Baker	Apple Box	√	√	√					H
Eucalyptus camaldulensis Dehnh.	River Red Gum		√						G
Eucalyptus camphora R.Baker subsp. *humeana* L.A.S.Johnson & K.Hill	Broad-leaved Sally		√	√					H
Eucalyptus chapmaniana Cameron	Bogong Gum			√					H
Eucalyptus dalrympleana Maiden subsp. *dalrympleana*	Mountain Gum		√	√	√				H
Eucalyptus delegatensis subsp. *delegatensis* R.Baker	Alpine Ash		√	√	√				H
Eucalyptus dives Schauer	Broad-leaved Peppermint	√	√	√					H
Eucalyptus fastigata Deane & Maiden	Brown Barrel		√	√					W
Eucalyptus glaucescens Maiden & Blakely	Tingiringi Gum		√	√	√				H
Eucalyptus globulus subsp. *bicostata* (Maiden, Blakely & Simmonds) J.B.Kirkp.	Eurabbie		√	√					M
Eucalyptus goniocalyx F.Muell. ex Miq.	Bundy	√	√	√					H
Eucalyptus kybeanensis Maiden & Cambage	Kybean Mallee			√					H
Eucalyptus lacrimans L.A.S.Johnson & K.Hill	Weeping Snow Gum			√	√	√			H
Eucalyptus macrorhyncha F.Muell. ex Benth.	Red Stringybark		√	√					H
Eucalyptus mannifera Mudie subsp. *mannifera*	Brittle Gum	√	√	√					H
Eucalyptus melliodora A.Cunn. ex Schauer	Yellow Box	√	√						H
Eucalyptus nortonii (Blakely) L.A.S.Johnson	Large-flowered Bundy	√	√						H
Eucalyptus ovata Labill.	Swamp Gum		√						A
Eucalyptus pauciflora subsp. *debeuzevillei* (Maiden) L.A.S.Johnson & Blaxell	Snow Gum				√				H
Eucalyptus pauciflora subsp. *niphophila* (Maiden & Blakely) L.A.S.Johnson & Blaxell	Snow Gum			√	√	√			H
Eucalyptus pauciflora Sieber ex Sprengel subsp. *pauciflora*	Snow Gum		√	√	√				H
Eucalyptus perriniana F.Muell. ex Rodway	Spinning Gum			√	√				H
Eucalyptus polyanthemos subsp. *polyanthemos* Schauer	Red Box	√	√						W
Eucalyptus radiata subsp. *robertsonii* (Blakely) L.A.S.Johnson & Blaxell	Robertson's Peppermint		√	√	√				H
Eucalyptus rossii R.Baker & H.G.Sm.	Inland Scribbly Gum			√					J
Eucalyptus rubida Deane & Maiden subsp. *rubida*	Candlebark	√	√	√	√				H
Eucalyptus saxatilis J.B.Kirkp. & Brooker	Suggan Buggan Mallee	√						E (TSC)	H
Eucalyptus stellulata Sieber ex DC.	Black Sally		√	√	√	√			H
Eucalyptus viminalis Labill.	Ribbon Gum		√	√	√				H
Euryomyrtus denticulata (Maiden & Betche) Trudgen				√					H
Kunzea ericoides (A.Rich.) Joy Thomps.	Burgan	√	√	√					H
Kunzea muelleri Benth.	Yellow Kunzea				√	√	√		H
Kunzea parvifolia Schauer	Crimson Kunzea		√	√					H
Leptospermum brevipes F.Muell.	Prickly Teatree		√						H
Leptospermum continentale Joy Thomps.	Prickly Teatree		√						H
Leptospermum grandifolium Sm.	Woolly Teatree		√	√	√				H
Leptospermum juniperinum Sm.	Prickly Tea-tree	√	√	√					H
Leptospermum lanigerum (Aiton) Sm.	Woolly Teatree			√					H
Leptospermum micromyrtus Miq.	Button Tea-tree		√	√	√				H
Leptospermum multicaule A.Cunn.	Silver Teatree		√						W

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Leptospermum myrtifolium Sieber ex DC.	Myrtle Tea-tree			√		√				H
Leptospermum obovatum Sweet	Creek Tea-tree			√						H
Leptospermum polygalifolium Salisb. subsp. *polygalifolium*	Tantoon Teatree			√						H
NYCTAGINACEAE										
Boerhavia dominii Meikle & Hewson	Tarvine	√								H
OLEACEAE										
* *Ligustrum vulgare* L.	European Privet			√					Cult	H
Notelaea ligustrina Vent.	Privet Mock-olive			√						H
* *Syringa vulgaris* L.	Common Lilac				√				Cult	T
ONAGRACEAE										
Epilobium billardiereanum Ser. subsp. *cinereum* (A.Rich.) Raven & Englehorn		√	√	√	√					H
Epilobium billardiereanum Ser. subsp. *hydrophilum* Raven & Englehorn				√	√					H
* *Epilobium ciliatum* Raf.	Glandular Willow-herb			√					Inv2	H
Epilobium curtisiae Raven	Bald-seeded Willow-herb				√	√				H
Epilobium gunnianum Hausskn.	Gunn's Willow-herb			√		√	√			H
Epilobium hirtigerum Cunn.	Hairy Willow-herb	√	√	√	√					H
Epilobium pallidiflorum Sol. ex A.Cunn	Showy Willow-herb				√					H
Epilobium sarmentaceum Hausskn.	Mountain Willow-herb				√		√			H
Epilobium tasmanicum Hausskn.	Snow Willow-herb						√			H
* *Oenothera glazioviana* M.Micheli	Evening Primrose	√	√	√					Unknown	H
* *Oenothera mollissima* L.			√						Nat	M
* *Oenothera rosea* L'Her. ex Aiton	Rose Evening Primrose				√				Cult	T
* *Oenothera stricta* Ledeb. ex Link subsp. *stricta*	Common Evening-primrose	√							Unknown	H
OROBANCHACEAE										
* *Orobanche minor* Sm.	Broomrape	√	√	√					Nat	H
* *Parentucellia latifolia* (L.) Caruel	Red Bartsia		√	√					Nat	H
OXALIDACEAE										
Oxalis chnoodes Lourteig		√								H
* *Oxalis corniculata* L.	Clover Sorrel								Unknown	H
Oxalis exilis A.Cunn.		√	√	√		√				H
Oxalis perennans Haw.			√	√	√					JB
Oxalis radicosa A.Rich.		√		√						M
PAPAVERACEAE										
* *Argemone ochroleuca* subsp. *ochroleuca* Sweet	Mexican Poppy	√							Unknown	H
* *Eschscholzia californica* Cham.	Californian Poppy	√		√					Nat	H
* *Fumaria officinalis* L.	Common Fumitory	√							Inv2	J

* *Fumaria muralis* Sonder ex Koch subsp. *muralis*	Wall Fumitory	√						Unknown	H
* *Papaver hybridum* L.	Rough Poppy		√					Nat	W
* *Papaver somniferum* subsp. *setigerum* (DC.) Thell.	Poppy	√						Inv2	H
PHRYMACEAE									
Glossostigma diandrum (L.) Kuntze	Spoon-leaf Mud-mat			√					J
Limosella australis R.Br.	Australian Mudwort	√				√			H
* *Mimulus guttatus* DC.	Monkey-flower			√				Nat	H
* *Mimulus moschatus* Douglas ex Lindley	Musk Monkey-flower			√		√		Inv2	H
PITTOSPORACEAE									
Billardiera longiflora Labill.	Purple Appleberry			√					H
Billardiera macrantha Hook.f.				√					H
Billardiera mutabilis Salis.	Climbing Appleberry		√						H
Billardiera scandens Sm.	Appleberry		√	√					H
Bursaria spinosa subsp. *lasiophylla* (E.M Benn.) L.W.Cayzer *et al.*	Blackthorn	√	√	√					H
Bursaria spinosa Cav. subsp. *spinosa*	Blackthorn		√	√					H
Pittosporum bicolor Hook.	Banyalla			√					H
Rhytidosporum alpinum McGillivray						√			H
Rhytidosporum inconspicuum L.Cayzer, Crisp & I.Telford	Alpine Appleberry					√			M
Rhytidosporum procumbens (Hook.) F.Muell.	White Marianth				√				W
PLANTAGINACEAE									
* *Callitriche stagnalis* Scop.	Common Starwort			√				Nat	M
Callitriche umbonata Hegelm.	Winged Water-starwort					√			H
Gratiola nana Benth.	Matted Brooklime		√			√			H
Gratiola peruviana L.	Australian Brooklime	√	√						H
* *Linaria arvensis* (L.) Desf.	Corn Toadflax	√	√			√		Inv1	H
* *Linaria pelisseriana* (L.) Mill.	Pelisser's Toadflax	√						Unknown	H
* *Linaria vulgaris* Mill.	Butter-and-Eggs							Unknown	MC
* *Misopates orontium* (L.) Raf.	Snapdragon				√			Cult	T
Plantago alpestris B.G.Briggs, Carolin & Pulley	Veined Plantain		√		√	√	√		H
Plantago antarctica Decne.	Mountain Plantain			√		√			H
Plantago debilis R.Br.	Shade Plantain			√	√				H
Plantago euryphylla B.G.Briggs, Carolin & Pulley	Broad Plantain					√	√		H
Plantago glacialis B.G.Briggs, Carolin & Pulley	Small Star Plantain						√		H
Plantago hispida R.Br.	Hairy Plantain	√		√	√	√			H
* *Plantago lanceolata* L.	Lamb's Tongues	√	√	√	√			Inv2	H
Plantago muelleri Pilger	Star Plantain						√		H
Plantago varia R.Br.	Variable Plantain	√	√	√		√			H
* *Veronica anagallis-aquatica* L.	Blue Water Speedwell	√	√	√				Nat	H
* *Veronica arvensis* L.	Wall Speedwell	√	√	√	√	√		Nat	H
Veronica calycina R.Br.	Hairy Speedwell		√	√					H
Veronica densifolia (F.Muell.) F.Muell.							√		H
Veronica derwentiana Andrews subsp. *derwentiana*	Derwent Speedwell		√	√	√	√			H
Veronica derwentiana subsp. *maideniana* (Gand.) B.G.Briggs				√	√				H
Veronica gracilis R.Br.	Slender Speedwell	√	√	√		√			H
Veronica nivea Lindl.	Milfoil Speedwell					√			H

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* *Veronica peregrina* L.	Wandering Speedwell	√		√					Nat	J
Veronica perfoliata R.Br.	Diggers Speedwell		√	√	√	√				H
Veronica plebeia R.Br.	Trailing Speedwell		√							W
* *Veronica serpyllifolia* L.	Thyme Speedwell					√	√		Inv2	H
Veronica subtilis B.G.Briggs & Ehrend.	Slender Speedwell		√	√	√					H
POLEMONIACEAE										
* *Collomia grandiflora* Douglas ex Lindl.				√	√				Inv1	H
* *Navarretia squarrosa* (Eschsch.) Hook. & Arn.	Californian Stinkweed		√						Unknown	H
POLYGALACEAE										
Comesperma ericinum DC.	Pyramid Flower		√							H
Comesperma retusum Labill.	Mountain Milkwort					√				H
Comesperma volubile Labill.	Blue Love Creeper		√							W
Polygala japonica Houtt.	Dwarf Milkwort		√	√						H
POLYGONACEAE										
* *Acetosella vulgaris* Fourr.	Sorrel / Sheep Sorrel	√	√	√	√	√	√		Inv3	H
Muehlenbeckia axillaris (Hook.f.) Walp.	Matted Lignum					√				H
Muehlenbeckia diclina subsp. Gippsland (R.O.Makinson 1007)	Weeping Lignum	√								H
Persicaria decipiens (R.Br.) K.L.Wilson	Slender Knotweed	√								J
Persicaria hydropiper (L.) Delarbre	Water Pepper	√	√							H
Persicaria lapathifolia (L.) Gray	Water Pepper	√	√							H
* *Persicaria maculosa* Gray	Jesus Plant	√							Inv1	H
Persicaria prostrata (R.Br.) Sojak	Creeping Knotweed	√	√	√						H
* *Polygonum arenastrum* Jord. ex Boreau	Wireweed					√			Nat	H
* *Polygonum aviculare* L.	Wireweed	√		√	√				Nat	H
Rumex brownii Campd.	Swamp Dock	√	√	√						H
* *Rumex conglomeratus* Murray	Clustered Dock	√							Inv2	H
* *Rumex crispus* L.	Curled Dock			√					Inv2	H
* *Rumex obtusifolius* L. subsp. *obtusifolius*	Broadleaf Dock			√	√				Unknown	H
* *Rumex pulcher* L. subsp. *pulcher*	Fiddle Dock								Unknown	MC
PORTULACACEAE										
Calandrinia eremaea Ewart	Small Purslane	√								H
Montia australasica (Hook.f.) Pax & K.Hoffm.	White Purslane					√	√			H
Montia fontana L. subsp. *chondrosperma* (Fenzl) Walters	Waterblinks					√				H
Portulaca oleracea L.	Pigweed	√								AC
PRIMULACEAE										
* *Lysimachia arvensis* (L.) U.Manns & Anderb.	Scarlet / Blue Pimpernel	√	√						Inv2	H

PROTEACEAE										
Banksia canei J.H.Willis	Mountain Banksia			√						H
Banksia marginata Cav.	Silver Banksia		√	√						H
Grevillea arenaria subsp. *canescens* (R.Br.) Olde & Marriott	Hoary Grevillea		√	√						H
Grevillea australis R.Br.	Alpine Grevillea				√	√	√			H
Grevillea brevifolia subsp. *brevifolia* F.Muell. ex Benth.	Cobberas Grevillea			√						J
Grevillea lanigera A.Cunn. ex R. Br.	Woolly Grevillea		√	√		√				H
Grevillea neurophylla Gand. subsp. *neurophylla*	Granite Grevillea		√	√						H
Grevillea oxyantha subsp. *ecarinata* Makinson				√						H
Grevillea parvula Molyneux & Stajsic	Genoa Grevillea		√							H
Grevillea ramosissima Meisn. subsp. *ramosissima*			√							H
Grevillea rosmarinifolia A.Cunn. subsp. *rosmarinifolia*	Rosemary Grevillea		√							H
Grevillea victoriae subsp. *nivalis* Stajsic & Molyneax	Kosciuszko Grevillea			√	√		√			H
Hakea eriantha R.Br.	Tree Hakea			√						H
Hakea lissosperma R.Br.	Needle Bush			√						H
Hakea microcarpa R.Br.	Small-fruited Hakea	√	√	√	√	√				H
Lomatia fraseri R.Br.	Silky Lomatia			√						H
Lomatia myricoides (C.F.Gaertn.) Domin	River Lomatia		√	√						H
Orites lancifolius F.Muell.	Alpine Orites				√	√	√			H
Persoonia chamaepeuce Lhotsky ex Meisn.	Dwarf Geebung		√	√	√	√				H
Persoonia confertiflora Benth.	Cluster-flower Geebung			√						H
Persoonia rigida R.Br.	Hairy Geebung	√		√						H
Persoonia silvatica L.A.S.Johnson	Forest Geebung		√	√						H
Persoonia subvelutina L.A.S.Johnson	Velvety Geebung		√	√	√					H
RANUNCULACEAE										
* *Aquilegia vulgaris* L.	Columbine						√		Cas	G
* *Batrachium trichophyllum* (Chaix) F.W.Schultz	Water Buttercup					√			Unknown	H
Clematis aristata R.Br. ex Ker Gawl.	Old Man's Beard		√	√	√					H
Clematis glycinoides DC.	Headache Vine				√					H
Clematis leptophylla (F.Muell. ex Benth.) H.Eichler	Skeleton Vine	√	√			√				H
Clematis microphylla DC.	Small-leaved Clematis		√			√				C
Psychrophila introloba (F.Muell.) W.A.Weber	Alpine Marsh-marigold					√	√			H
Ranunculus acrophilus B.G.Briggs							√			H
Ranunculus amphitrichus Colenso	Small River Buttercup			√		√				H
Ranunculus anemoneus F.Muell.	Anemone Buttercup						√	V (TSC)		H
Ranunculus clivicola B.G.Briggs						√	√			H
Ranunculus collinus R.Br. ex DC.	Strawberry Buttercup					√				H
Ranunculus diminutus B.G.Briggs	Brackish Plains Buttercup					√				H
Ranunculus dissectifolius F.Muell. ex Benth.					√	√	√			H
Ranunculus graniticola Melville	Granite Buttercup		√	√	√	√	√			H
Ranunculus gunnianus Hook.	Gunn's Alpine Buttercup				√	√	√			H
Ranunculus inundatus R.Br. ex DC.	River Buttercup					√				W
Ranunculus lappaceus Sm.	Common Buttercup		√	√	√					H
Ranunculus millanii F.Muell.	Dwarf Buttercup				√	√	√			H
Ranunculus muelleri Benth.	Felted Buttercup					√	√			H

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* *Ranunculus muricatus* L.	Sharp Buttercup								Unknown	MC
Ranunculus niphophilus B.G.Briggs	Snow Buttercup					√	√			H
Ranunculus papulentus Melville	Large River Buttercup					√				H
Ranunculus pimpinellifolius Hook.	Bog Buttercup					√				H
Ranunculus plebeius R.Br. ex DC.	Forest Buttercup		√		√					H
Ranunculus productus B.G.Briggs						√				H
Ranunculus pumilio R.Br. ex DC. var. *pumilio*	Ferny Buttercup			√		√				H
* *Ranunculus repens* L.	Creeping Buttercup								Unknown	MC
Ranunculus scapiger Hook.			√	√	√					H
Ranunculus sessiliflorus R.Br. ex DC. var. *sessiliflorus*	Small-flowered Australian Buttercup		√							H
RESEDACEAE										
* *Reseda luteola* L.	Weld	√	√						Nat	H
RHAMNACEAE										
Cryptandra amara Sm.	Bitter Cryptandra	√	√			√				H
Discaria nitida Tortosa	Shining Anchor Plant		√	√	√	√		V (TSC)		H
Discaria pubescens (Brongn.) Druce	Australian Anchor Plant		√	√	√	√				H
Pomaderris angustifolia (Benth.) N.A.Wakef.			√							H
Pomaderris aspera Sieber ex DC.	Hazel Pomaderris	√	√	√						H
Pomaderris betulina A.Cunn. ex Hook. subsp. *betulina*	Birch Pomaderris	√	√	√						H
Pomaderris cotoneaster N.A.Wakef.	Cotoneaster Pomaderris		√					E (TSC)		H
Pomaderris intermedia Sieber ex DC.	Lemon Dogwood		√							W
Pomaderris lanigera (Andrews) Sims	Woolly Pomaderris		√							H
Pomaderris ledifolia A.Cunn.	Sydney Pomaderris	√								H
Pomaderris pallida N.A.Wakef.	Pale Pomaderris	√						V (TSC)		C
Pomaderris phylicifolia subsp. *ericoides* (Maiden & Betche) N.G.Walsh & Coates	Slender Pomaderris			√	√					H
Pomaderris phylicifolia subsp. *phylicifolia* Lodd. ex Link	Slender Pomaderris	√	√							
Pomaderris subcapitata N.A.Wakef.	Convex Pomaderris		√							H
Pomaderris velutina J.H.Willis	Velvety Pomaderris		√							H
Spyridium parvifolium (Hook.) F.Muell.	Dusty Miller		√							H
ROSACEAE										
Acaena agnipila Gand.		√	√							H
Acaena echinata Nees	Sheep's Burr	√	√	√	√	√				H
Acaena novae-zelandiae Kirk	Bidgee-widgee	√	√	√	√	√				H
Acaena ovina A.Cunn.	Sheep's Burr	√	√	√		√				H
Acaena sp. Thredbo River Gorge (L.A.S.Johnson & E.F.Constable s.n., 19 Jan 1951) NSW Herbarium					√		√			H
* *Aphanes arvensis* L.	Parsley-piert					√			Nat	H

Alchemilla xanthochlora Rothm.	Lady’s Mantle				√		√		H
* *Cotoneaster glaucophyllus* Franch.	Bright Bead Cotoneaster		√					Nat	M
* *Cotoneaster horizontalis* Decne.	Rock Cotoneaster				√			Nat	T
* *Cotoneaster pannosus* Franch.	Silverleaf Cotoneaster		√					Nat	M
* *Cotoneaster rotundifolius* Wall. ex Lindl.						√		Inv1	H
* *Crataegus monogyna* Jacq.	Hawthorn			√				Inv1	F
Geum urbanum L.	Herb Bennett			√	√	√			H
* *Malus pumila* Mill.	Apple		√	√	√			Cas	M
* *Photinia glabra* (Thunb.) Franch. & Sav.					√			Cult	T
* *Potentilla recta* L	Erect Cinquefoil			√		√		Inv2	H
* *Potentilla vesca* (L.) Scop.	European Strawberry				√			Inv1	J
* *Prunus cerasus* L.	Sour Cherry			√				Cas	W
* *Pyracantha crenulata* (D.Don) M.Roem.	Pyracantha		√					Inv1	M
* *Rosa rubiginosa* L.	Sweet Briar	√	√	√		√		Inv2	H
* *Rubus anglocandicans* A.Newton	Blackberry			√				Inv4	H
* *Rubus leucostachys* Schleich. ex Sm.	Blackberry		√	√				Inv4	H
* *Rubus polyanthemus* Lindb.	Blackberry		√					Inv4	H
Rubus parvifolius L.	Native Raspberry	√	√	√	√				H
* *Rubus vestitus* Weihe	Blackberry					√		Inv4	H
**Sanguisorba minor* subsp. *muricata* (Spach) Briq.	Sheep’s Burnett		√					Inv1	H
* *Sorbus aucuparia* L.	Rowan			√				Nat	K
* *Spiraea x billiardii* Herincq				√				Inv1	H
RUBIACEAE					√				H
Asperula conferta Hook.f.	Common Woodruff	√	√	√	√	√			H
Asperula gunnii Hook.f.	Mountain Woodruff			√	√	√	√		H
Asperula polymera I.Thomps.			√	√					H
Asperula pusilla Hook.f.	Alpine Woodruff			√	√	√	√		H
Asperula scoparia Hook.f. subsp. *scoparia*	Prickly Woodruff		√	√	√	√			H
Coprosma hirtella Labill.	Coffee-berry		√	√	√				H
Coprosma niphophila Orchard							√		H
Coprosma nivalis W.R.B.Oliver	Snow Coprosma					√			H
Coprosma perpusilla Colenso subsp. *perpusilla*	Creeping Coprosma						√		H
Coprosma quadrifida (Labill.) B.L.Rob.	Prickly Currant Bush		√	√	√				H
* *Galium aparine* L.	Goosegrass	√	√					Inv1	H
Galium ciliare Hook.f. subsp. *ciliare*				√					H
Galium liratum N.A.Wakef.	Furrowed Bedstaw		√						J
* *Galium divaricatum* Lam.	Slender Bedstraw			√				Nat	H
Galium gaudichaudii DC. subsp. *gaudichaudii*	Rough Bedstraw	√	√	√					H
Galium leiocarpum I.Thomps.			√						H
* *Galium murale* (L.) All.	Small Bedstraw	√						Unknown	H
Galium polyanthum I.Thomps.				√					H
Galium roddii Ehrend. & McGill.						√			H
Leptostigma reptans (F.Muell.) Fosberg	Dwarf Nertera		√						J
Nertera granadensis (Mutis ex L.f.) Druce	Matted Nertera					√	√		H
Opercularia varia Hook.f.	Variable Stinkweed		√						M

Group / Family / Taxon	**Common Name**	**Lower Snowy <700m**	**Tableland Forest 400–1000m**	**Montane Forest 1000m–1400m**	**Subalpine Snowgum 1400m–1800m**	**Subalpine / Montane Treeless <1800m**	**Alpine >1800m**	**Legal Status**	**Alien Status**	**Source**
* *Sherardia arvensis* L.	Field Madder	√							Unknown	MC
RUTACEAE										
Asterolasia asteriscophora (F.Muell.) Druce	Lemon Starbush		√	√						H
Asterolasia trymalioides F.Muell.	Alpine Starbush					√				H
Boronia algida F.Muell.	Alpine Boronia				√					H
Boronia anemonifolia A.Cunn. subsp. *anemonifolia*		√	√							H
Boronia nana Hook. var. *hyssopifolia* Melville	Small Boronia		√							H
Correa lawrenceana Hook. var. *latrobeana* (F.Muell. ex Hannaford) Paul G.Wilson	Mountain Correa			√						H
Correa lawrenceana Hook. var. *rosea* Paul G.Wilson	Mountain Correa		√							H
Correa reflexa (Labill.) Vent. var *reflexa*	Common Correa		√							W
Crowea exalata F.Muell. subsp. *exalata*	Small Crowea	√								H
Leionema lamprophyllum subsp. *obovatum* F.M.Anderson		√								H
Leionema phylicifolium (F.Muell.) Paul G.Wilson	Mountain Phebalium					√				H
Nematolepis ovatifolia (F.Muell.) Paul G.Wilson					√	√	√			H
Phebalium glandulosum subsp. *riparium* R.L.Giles	Snowy River Phebalium	√								H
Phebalium squamulosum subsp. *alpinum* (Benth.) Paul G.Wilson	Alpine Phebalium					√	√			H
Phebalium squamulosum subsp. *ozothamnoides* (F.Muell.) Paul G.Wilson	Alpine Phebalium					√				H
Phebalium squamulosum subsp. *squamulosum* Vent.	Forest Phebalium			√	√					H
Philotheca myoporoides (DC.) Bayly subsp. *myoporoides*	Long-leaf Waxflower		√	√						H
Philotheca trachyphylla (F.Muell.) Paul G.Wilson	Rock Waxflower	√	√							H
Zieria cytisoides Sm.	Downy Zieria	√								H
SALICACEAE										
* *Populus alba* L.	White Poplar				√				Cult	T
* *Salix alba* L.	White Willow	√							Inv1	H
* *Salix babylonica* L.	Weeping Willow								Inv2	W
* *Salix cinerea* L.	Pussy Willow					√			Inv2	H
* *Salix x fragilis* Schrank	Crack Willow					√			Inv2	H
* *Salix nigra* Marshall	Black Willow		√						Inv1	
* *Salix purpurea* L.	Purple Osier				√				Inv2	H
* *Salix viminalis* L.	Common Osier			√	√				Nat	H
SAMBUCACEAE										
Sambucus gaudichaudiana DC.	White Elderberry			√						H
* *Sambucus nigra* L.	Common Elder								Cult	W
SANTALACEAE										
Choretrum pauciflorum A.DC.	Dwarf Sour Bush		√	√						H
Exocarpos cupressiformis Labill.	Cherry Ballart	√	√	√						H
Exocarpos nanus Hook.f.	Alpine Ballart					√	√			H

Exocarpos strictus R.Br.	Dwarf Cherry	√	√	√						H
Omphacomeria acerba (R.Br.) A.DC.	Leafless Sourbush		√	√						H
Thesium australe R.Br.	Austral Toadflax		√	√		√		V (TSC)		H
SAPINDACEAE										
Dodonaea viscosa Jacq. subsp. *angustissima* (DC.) J.G.West	Narrow-leaved Hop-bush	√	√							H
Dodonaea viscosa Jacq. subsp. *cuneata* (Sm.) J.G.West	Wedge-leaf Hop-bush		√							H
Dodonaea viscosa Jacq. subsp. *spatulata* J.G.West	Sticky Hop-Bush	√	√							H
SCROPHULARIACEAE										
Euphrasia alsa F.Muell.	Dwarf Eyebright						√			H
Euphrasia caudata (J.H.Willis) W.R.Barker	Tail Eyebright					√				H
Euphrasia collina subsp. *diversicolor* W.R.Barker	Purple Eyebright					√	√			H
Euphrasia collina subsp. *glacialis* (Wettst.) W.R.Barker					√		√			H
Euphrasia collina subsp. *lapidosa* W.R.Barker						√	√			H
Euphrasia collina subsp. *paludosa* (R.Br.) W.R.Barker	Swamp Eyebright			√		√	√			H
Euphrasia scabra R.Br.				√				E (TSC)		H
Euphrasia sp. 3 (Ramshead Range) sensu W.R.Barker (1982)							√			H
* *Verbascum blattaria* L.	Moth Mullein		√						Unknown	MC
* *Verbascum thapsus* L. subsp. *thapsus*	Aaron's Rod		√	√	√	√			Inv2	H
* *Verbascum virgatum* Stokes	Twiggy Mullein					√			Inv2	H
SOLANACEAE										
Cyphanthera albicans (A.Cunn.) Miers subsp. *albicans*	Grey Ray Flower	√								G
* *Datura stramonium* L.	Common Thornapple	√							Unknown	MC
Nicotiana suaveolens Lehm.	Native Tobacco	√	√							H
Solanum aviculare G.Forst.	Kangaroo Apple	√								W
* *Solanum chenopodioides* Lam.	Whitetip Nightshade	√	√						Cas	H
Solanum linearifolium Geras. ex Symon	Mountain Kangaroo Apple	√								H
* *Solanum nigrum* L.	Black-berry Nightshade	√	√						Unknown	MC
* *Solanum triflorum* Nutt.	Three-flowered Nightshade	√	√						Unknown	H
STYLIDIACEAE										
Stylidium armeria (Labill.) Labill.	Thrift-leaved Triggerplant		√	√	√	√				H
Stylidium graminifolium Sw.	Grass Triggerplant		√							H
Stylidium montanum Raulings & Ladiges	Alpine Triggerplant					√	√			H
THYMELAEACEAE										
Kelleria dieffenbachii (Hook.) Endl.							√			H
Pimelea alpina F.Muell. ex Meisn.	Alpine Rice-flower				√	√	√			H
Pimelea axiflora subsp. *alpina* (Benth.) Threlfall	Alpine Bootlace Bush					√	√			H
Pimelea axiflora F.Muell. ex Meisn. subsp. *axiflora*	Bootlace Bush	√		√	√					H
Pimelea biflora N.A.Wakef.	Matted Rice-flower				√	√				H
Pimelea bracteata Threlfall	Rice-flower					√				H
Pimelea curviflora var. *acuta* Threlfall				√						H
Pimelea curviflora var. *gracilis* (R.Br.) Threlfall	Curved Rice-flower		√							H
Pimelea curviflora var. *sericea* Benth.	Silky Curved Rice-flower	√	√	√						H
Pimelea glauca R.Br.	Smooth Rice-flower		√	√	√					H
Pimelea ligustrina subsp. *ciliata* Threlfall	Fringed Rice-flower			√	√	√	√			H

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Pimelea ligustrina subsp. *ligustrina* Labill.	Tall Rice-flower				√					
Pimelea linifolia subsp. *caesia* Threlfall	Slender Rice-flower					√				H
Pimelea linifolia Sm. subsp. *linifolia*	Queen of the Bush		√	√	√					H
Pimelea pauciflora R.Br.	Few-flowered Pimelea		√	√		√				H
Pimelea treyvaudii F.Muell. ex Ewart & B.Rees	Grey Rice-flower		√							H
TREMANDRACEAE										
Tetratheca bauerifolia F.Muell. ex Schuch.	Heath Pink-bells		√	√	√	√				H
Tetratheca ciliata Lindl.	Pink Bells			√						H
Tetratheca ericifolia Sm.	Pink Eye			√		√				H
Tetratheca labillardierei Joy Thomps.	Glandular Pink-bells		√							H
Tetratheca subaphylla Benth.	Leafless Pink-bells		√	√						H
Tetratheca thymifolia Sm.	Thyme Pink-bells		√							H
ULMACEAE										
* *Ulmus procera* Salisb.	English Elm				√				Cult	T
URTICACEAE										
Australina pusilla (Poir.) Gaudich.	Small Shade Nettle		√	√						H
Urtica incisa Poir.	Stinging Nettle	√	√	√						H
VERBENACEAE										
* *Verbena bonariensis* L.	Purpletop		√	√					Nat	M
* *Verbena officinalis* L.	Common Verbena	√							Inv1	H
* *Verbena supina* L.	Trailing Verbena		√	√					Cas	H
VIOLACEAE										
Hybanthus monopetalus (Schult.) Domin	Slender Violet-bush		√	√						H
Hybanthus vernonii (F.Muell.) F.Muell. subsp. *vernonii*	Erect Violet			√						H
Melicytus dentatus (R.Br. ex DC.) Molloy & Mabb.	Tree Violet		√	√	√					H
Melicytus sp. Snowfields (N.G.Walsh 6202) Vic. Herbarium						√	√			H
* *Viola arvensis* Murray	Field Pansy					√			Inv2	H
Viola betonicifolia Sm.	Native Violet	√	√	√	√	√	√			H
Viola fuscoviolacea (L.G.Adams) T.A.James	Dusky Violet				√					H
Viola hederacea Labill.	Ivy-leaved Violet		√	√	√					W
* *Viola odorata* L.	Sweei Violet					√			Nat	
WINTERACEAE										
Tasmannia lanceolata (Poir.) A.C.Sm.	Mountain Pepperbush		√	√	√					H
Tasmannia xerophila (P.Parm.) M. Gray subsp. *xerophila*	Alpine Pepperbush		√	√	√	√	√			H

MONOCOTYLEDONS

AGAPANTHACEAE										
* *Agapanthus praecox* Willd.	African Lily				√				Cult	T
ALSTROEMERIACEAE										
**Alstroemeria aurea* Graham	Lily of the Incas			√	√				Cult	H
AMARYLLIDACEAE										
* *Narcissus* spp.	Daffodil					√			Nat	K
ASPARAGACEAE										
Arthropodium milleflorum (DC.) J.F.Macbr	Vanilla Lily	√	√	√	√	√				H
Arthropodium minus R.Br.	Small Vanilla Lily	√	√							H
Arthropodium sp. Snowy R. catchment (N.G.Walsh 6195) Vic. Herbarium		√	√	√	√					H
Lomandra filiformis (Thunb.) Britten subsp. *filiformis*	Wattle Mat-rush	√	√	√						W
Lomandra longifolia Labill.	Spiny-headed Mat-rush	√	√	√	√					H
Lomandra multiflora (R.Br.) Britten subsp. *multiflora*	Many-flowered Mat-rush	√	√	√						W
* *Muscari armeniacum* Leichtlin ex Baker	Grape Hyacinth				√				Cult	T
Thysanotus tuberosus R.Br.	Common Fringe Lily			√						H
ASPHODELACEAE										
* *Asphodelus fistulosus* L.	Onion Weed	√							Nat	H
Bulbine bulbosa (R.Br.) Haw.	Bulbine Lily		√	√	√	√				H
Bulbine glauca (Raf.) E.M.Watson	Rock Lily	√				√				H
**Ornithogalum umbellatum* L.	Star of Bethlehem					√			Nat	K
ASTELIACEAE										
Astelia alpina var. *novae-hollandiae* Skottsb.	Pineapple Grass					√	√			H
Astelia psychrocharis F.Muell.	Kosciuszko Pineapple Grass				√	√	√			H
COLCHICACEAE										
Burchardia umbellata R.Br.	Milkmaids		√							W
Wurmbea biglandulosa (R.Br.) T.D.Macfarl. subsp. *biglandulosa*	Glandular Early Nancy		√	√						H
Wurmbea dioica (R.Br.) F.Muell. subsp. *dioica*	Early Nancy			√						J
COMMELINACEAE										
* *Tradescantia* sp.					√				Cult	T
CYPERACEAE										
Baumea gunnii (Hook.f.) S.T.Blake			√			√				H
Bolboschoenus fluviatilis (Torr.) Sojak	Marsh Club-rush	√								H
Bolboschoenus medianus (V.J.Cook) Sojak	Marsh Club-rush	√								H
Carex appressa R.Br.	Tall Sedge	√	√	√	√	√	√			H
Carex archeri Boott	Archer's Carex						√	E (TSC)		H
Carex blakei Nelmes	Alpine Sedge			√		√				H
Carex breviculmis R.Br.		√	√	√	√	√	√			H
Carex canescens L.	Short Sedge					√	√			H
Carex chlorantha R.Br.						√	√			H
Carex echinata Murray	Star Sedge			√	√	√	√			H
Carex fascicularis Sol. ex Boott	Tassel Sedge			√	√					H

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Carex gaudichaudiana Kunth						√	√			H
Carex hebes Nelmes						√	√			H
Carex hypandra F.Muell. ex Benth.	Alpine Fen-sedge						√			H
Carex incomitata K.R.Thiele			√	√		√				H
Carex inversa R.Br.	Knob Sedge	√	√	√						H
Carex iynx Nelmes	Bergarlia Tussock		√	√						H
Carex jackiana Boott	Carpet Sedge					√	√			H
Carex longebrachiata Boeckeler	Bergarlia Tussock				√					H
Carex polyantha F.Muell.			√							H
Carex pyrenaica var. *cephalotes* (F.Muell.) Kuk.	Wire-head Sedge					√	√			H
Carex raleighii Nelmes	Raleigh Sedge					√		E (TSC)		H
Carex rara subsp. *capillacea* (Boott) Kuk.	Hair Sedge					√	√			H
Carex tereticaulis F.Muell				√	√					H
Carpha alpina R.Br.	Small Flower-rush					√	√			H
Carpha nivicola F.Muell.	Broad-leaf Flower-rush				√	√	√			H
* *Cyperus eragrostis* Lam.	Umbrella Sedge		√						Unknown	H
Cyperus lhotskyanus Boeckeler	Flat-sedge	√								H
Cyperus lucidus R.Br.	Leafy Flat-sedge		√							H
Cyperus sanguinolentus Vahl	Dark Flat-sedge		√	√						H
* *Cyperus tenellus* L.f.	Tiny Flat-sedge								Unknown	W
Eleocharis acuta R.Br.	Common Spike-rush		√	√	√					H
Eleocharis gracilis R.Br.	Slender Spike-rush		√							H
Eleocharis plana S.T.Blake	Ribbed Spike-rush		√							J
Eleocharis pusilla R.Br.	Small Spike-rush				√					H
Isolepis aucklandica Hook.f.						√	√			H
Isolepis cernua (Vahl) Roem. & Schult.	Nodding Club-rush	√	√							H
Isolepis congrua Nees	Slender Club-sedge			√						J
Isolepis crassiuscula Hook.f.	Alpine Club-rush			√		√	√			H
Isolepis fluitans (L.) R.Br.	Floating Club-rush		√			√				H
Isolepis gaudichaudiana Kunth	Benambra Club-sedge			√	√	√	√			H
Isolepis habra (Edgar) Sojak	Whispy Club-sedge					√	√			H
Isolepis inundata R.Br.	Swamp Club-rush		√	√						H
* *Isolepis marginata* (Thunb.) A.Dietr	Coarse Club-rush					√			Nat	H
Isolepis montivaga (S.T.Blake) K.L.Wilson	Fog Club-sedge					√	√			H
Isolepis multicaulis Schltdl.			√							M
Isolepis producta (C.B.Clarke) K.L.Wilson	Nutty Clud-rush					√				K ?????
Isolepis subtilissima Boeckeler				√		√	√			H
Lepidosperma curtisiae K.L.Wilson & D.I.Morris						√				H
Lepidosperma gunnii Boeckeler	Little Sword-sedge	√	√							J

Lepidosperma laterale R.Br.	Variable Sword-sedge	√	√						H
Oreobolus distichus F.Muell.					√	√	√		H
Oreobolus oxycarpus S.T.Blake subsp. *oxycarpus*	Tuft-rush					√	√		H
Oreobolus pumilio R.Br.	Alpine Tuft-rush					√	√		H
Schoenus apogon Roem. & Schult.	Common Bog-rush	√		√					H
Schoenus calyptratus Kuk.	Alpine Bog-rush					√	√		H
Schoenus latelaminatus Kuk.	Medusa Bog-sedge	√							CO
Scirpus polystachyus F.Muell.	Large-headed Club-rush			√					H
Uncinia compacta R.Br.	Compact Hook-sedge						√		H
Uncinia flaccida S.T.Blake	Mountain Hook-sedge				√		√		H
Uncinia sinclairii Boott							√		H
Uncinia sulcata K.L.Wilson	Small Hook-sedge						√		H
Uncinia tenella R.Br.	Delicate Hook-sedge			√					H
HEMEROCALLIDACEAE									
Caesia alpina Hook.f.	Alpine Grass Lily					√			H
Dianella longifolia R.Br. var. *longifolia*	Blueberry Lily		√						H
Dianella revoluta R.Br.	Black-anther Flax-lily	√	√	√					H
Dianella tasmanica Hook.f.	Tasman Flax-lily		√	√	√		√		H
Herpolirion novae-zelandiae Hook.f.	Sky Lily				√	√	√		H
Stypandra glauca R. Br.	Nodding Blue Lily	√	√						H
HYPOXIDACEAE									
Hypoxis hygrometrica var. *hygrometrica* Labill.	Golden Weathergrass			√		√			H
Hypoxis hygrometrica var. *villosisepala* R.J.F.Hend	Golden Weathergrass			√		√			H
Hypoxis vaginata var. *vaginata* Schltdl.	Yellow Star		√						H
IRIDACEAE									
Diplarrena moraea Labill.	White Iris		√						W
* *Iris germanica* L.	Tall Bearded Iris		√		√	√		Inv1	M
Patersonia sericea var. *longifolia* (R.Br.) C.Moore & Betche	Purple Flag					√			H
* *Romulea minutiflora* Klatt	Small Flowered Onion Grass							Unknown	W
* *Sisyrinchium iridifolium* Kunth.	Blue Pigroot		√					Nat	H
JUNCACEAE									
Juncus alexandri L.A.S.Johnson subsp. *alexandri*				√		√			H
Juncus antarcticus Hook.f.	Cushion Rush						√		H
* *Juncus articulatus* L.	Jointed Rush					√		Inv2	H
Juncus australis Hook.f.	Austral Rush		√			√			H
Juncus brevibracteus L.A.S.Johnson	Alpine Rush					√			H
* *Juncus bufonius* L.	Toad Rush	√	√	√				Nat	H
* *Juncus capitatus* Weigel	Capitate rush		√					Nat	M
* *Juncus effusus* L.	Soft Rush		√	√	√			Inv2	H
Juncus falcatus E.Mey.	Sickle-leaf Rush					√	√		H
Juncus filicaulis Buchenau	Thread Rush		√	√	√	√			H
Juncus fockei Buchenau	Slender Joint-leaf Rush		√	√					H
Juncus gregiflorus L.A.S.Johnson		√	√						H
Juncus homalocaulis F.Muell. ex Benth.	Wiry Rush	√	√						J

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Juncus pauciflorus R.Br.	Loose Flower Rush		√							M
Juncus phaeanthus L.A.S.Johnson	Dark-flower Rush					√				H
Juncus planifolius R.Br.	Broad Leaved Rush	√								J
Juncus sandwithii Lourteig	Alpine Joint-leaf Rush			√		√				H
Juncus sarophorus L.A.S.Johnson	Broom Rush		√							H
Juncus subsecundus N.A.Wakef.	Finger Rush			√						H
* *Juncus tenuis* Willd.	Slender Rush		√	√					Inv2	H
Juncus thompsonianus L.A.S.Johnson	Snowfield Rush						√			H
Juncus usitatus L.A.S.Johnson	Common Rush			√						H
Juncus vaginatus R.Br.	Clustered Rush		√	√						H
Luzula acutifolia subsp. *nana* Edgar							√			H
Luzula alpestris H.Nordensk.	Tussock Woodrush					√	√			H
Luzula atrata Edgar	Slender Woodrush					√	√			H
Luzula australasica subsp. *dura* (Edgar) M.E.Jansen							√			H
Luzula densiflora (H.Nordensk.) Edgar			√	√	√					H
Luzula flaccida (Buchenau) Edgar	Pale Wood-rush		√	√	√	√				H
Luzula meridionalis H.Nordensk.	Field Woodrush		√	√						H
Luzula modesta Buchenau					√	√	√			H
Luzula novae-cambriae Gand.					√	√	√			H
Luzula ovata Edgar	Clustered Wood-rush				√					H
LUZURIAGACEAE										
Drymophila cyanocarpa R.Br.	Turquoise Berry			√						H
ORCHIDACEAE										
Arthrochilus huntianus (F.Muell.) Blaxell	Elbow Orchid			√						H
Caladenia alpina R.S.Rogers	Mountain Caladenia		√	√	√	√	√			H
Caladenia carnea R.Br.	Pink Fingers		√							H
Caladenia congesta R.Br.	Black Tongue Caladenia		√							H
Caladenia gracilis R.Br.	Musky Caladenia		√							H
Chiloglottis cornuta Hook.f.	Green Bird Orchid			√	√	√				H
Chiloglottis gunnii Lindl.	Ant Orchid			√						H
Chiloglottis trilabra Fitz.			√							H
Chiloglottis turfosa D.L.Jones						√				H
Chiloglottis valida D.L.Jones	Large Bird Orchid		√	√						H
Corysanthes hispida (D.L.Jones) D.L.Jones & M.A.Clem.	Bristly Helmet Orchid	√	√							G
Cyrtostylis reniformis R.Br.	Gnat Orchid		√							G
Dendrobium striolatum Rchb.f.	Streaked Rock Orchid		√							G
Dipodium punctatum (Sm.) R.Br.				√						H
Dipodium roseum D.L.Jones & M.A.Clem.			√	√						H

Diuris monticola D.L.Jones					√		H
Diuris ochroma D.L.Jones	Pale Golden Moths				√	E (TSC)	H
Diuris subalpina D.L.Jones					√		H
Diuris sulphurea R.Br.	Tiger Orchid		√	√	√		H
Eriochilus cucullatus (Labill.) Rchb.f.	Parson's Bands	√	√				H
Eriochilus magenteus D.L.Jones				√			MCL
Gastrodia procera G.W.Carr				√	√		H
Gastrodia sesamoides R.Br.	Potato Orchid	√	√	√			H
Genoplesium archeri (Hook.f.) D.Jones & M.Clements	Variable Midge Orchid			√			H
Genoplesium nudum (Hook.) D.Jones & M.Clements	Tiny Midge Orchid	√	√				H
Genoplesium turfosum D.L.Jones					√		H
Glossodia major R.Br.	Waxlip Orchid	√					W
Microtis oblonga R.S.Rogers			√				H
Microtis parviflora R.Br.	Slender Onion Orchid		√				H
Microtis rara R.Br.	Scented Onion		√				H
Microtis unifolia (G.Forst.) Rchb.f.	Common Onion Orchid	√	√				W
Petalochilus gracillimus (Rupp) D.L.Jones & M.A.Clem.				√			H
Prasophyllum alpestre D.L.Jones	Alpine Leek Orchid				√	√	H
Prasophyllum brevilabre (Lindl.) Hook.f.	Short-lipped Leek Orchid		√	√			H
Prasophyllum candidum R.J.Bates & D.L.Jones					√		H
Prasophyllum innubum D.L. Jones					√	CE (EPBC)	H
Prasophyllum montanum R.J.Bates & D.L.Jones	Mountain Leek Orchid			√	√		H
Prasophyllum odoratum R.S.Rogers	Rogers Scented Leek Orchid				√		H
Prasophyllum retroflexum D.L.Jones	Congested Leek Orchid				√	V (TSC)	H
Prasophyllum sphacelatum D.L.Jones					√		H
Prasophyllum tadgellianum (R.S.Rogers) R.S.Rogers					√	√	H
Prasophyllum venustum D.L.Jones & D.T.Rouse			√				MCL
Pterostylis aciculiformis (Nicholls) M.A.Clem. & D.L.Jones	Slender Ruddyhood	√					H
Pterostylis alpina R.S.Rogers			√				H
Pterostylis aneba D.L.Jones				√			H
Pterostylis atrans D.L.Jones	Blunt-tongue Greenhood		√				H
Pterostylis crassicaulis (D.L.Jones) G.N.Backh.			√	√	√		H
Pterostylis curta R.Br.	Blunt Greenhood		√				H
Pterostylis cycnocephala Fitzg.				√	√		H
Pterostylis decurva R.S.Rogers	Summer Greenhood				√		W
Pterostylis dubia R.Br				√	√		H
Pterostylis falcata R.S.Rogers	Sickle Greenhood		√	√			H
Pterostylis foliata Hook.f.	Slender Greenhood		√				H
Pterostylis furcata Lindl.	Sickle Greenhood		√	√	√		H
Pterostylis melagramma D.L.Jones		√	√				M
Pterostylis monticola D.L.Jones	Mountain Greenhood			√	√		H
Pterostylis multiflora (D.L.Jones) G.N.Backh.				√			H
Pterostylis mutica R.Br.	Midget Greenhood				√		H
Pterostylis nutans R.Br.	Nodding Greenhood		√				H

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Pterostylis oreophila Clemesha	Blue-tongue Greenhood					√		E (TSC)		H
Pterostylis parviflora R.Br.	Tiny Greenhood		√							H
Pterostylis robusta R.S.Rogers	Large Striped Greenhood				√					H
Spiranthes australis (R.Br.) Lindl.	Ladies Tresses					√				W
Thelymitra alpicola Jeanes	Alpine Sun Orchid				√					H
Thelymitra alpina Jeanes					√	√				H
Thelymitra arenaria Lindl.				√						H
Thelymitra cyanea (Lindl.) Benth.	Veined Sun Orchid		√	√		√				H
Thelymitra juncifolia Lindl.			√	√	√					H
Thelymitra megcalyptra Fitzg.	Scented Sun Orchid		√	√						H
Thelymitra nuda R.Br.	Plain Sun Orchid			√	√	√				H
Thelymitra pauciflora R.Br.	Slender Sun Orchid		√	√	√					W
Thelymitra simulata D.L.Jones et M.A.Clem.	Graceful Sun Orchid			√	√	√				H
Thelymitra truncata R. Rogers					√					H
POACEAE										
Agrostis australiensis Mez.	Australian Bent					√	√			H
Agrostis bettyae S.W.L.Jacobs	Alpine Winter Bent			√		√	√			H
* *Agrostis capillaris* L.	Browntop Bent			√		√	√		Inv2	H
* *Agrostis gigantea* Roth	Redtop Bent								Unknown	H
Agrostis joyceae S.W.L.Jacobs	Hair Bent					√	√			H
Agrostis muelleriana Vickery	Mueller'sBent					√	√			H
Agrostis parviflora R.Br.	Hair Bent		√			√	√			H
Agrostis propinqua S.W.L.Jacobs	Mountain Bent					√	√			H
* *Agrostis stolonifera* L.	Creeping Bent					√	√		Nat	H
Agrostis thompsoniae S.W.L.Jacobs	Alpine Bent					√				H
Agrostis venusta Trin.	Graceful Bent				√	√	√			H
* *Aira caryophyllea* L.	Silvery Hairgrass	√	√			√			Inv3	H
* *Aira cupaniana* Guss.	Silvery Hairgrass	√	√						Inv2	M
* *Aira elegantissima* Schur	Delicate Hairgrass	√	√			√			Nat	H
* *Aira praecox* L.	Early Hairgrass		√	√					Inv2	M
* *Alopecurus aequalis* Sobol.	Short-awned Foxtail					√			Inv1	H
* *Anthoxanthum odoratum* L.	Sweet Vernal Grass			√	√	√	√		Inv4	H
Aristida benthamii var. *benthamii* Henrard	Three-awned Spear Grass		√	√						J
Aristida ramosa R.Br.	Purple Wiregrass	√				√				H
* *Arrhenatherum elatius* var. *bulbosum* (Willd.) Spenn.	Bulbous Oatgrass				√	√			Inv2	H
Australopyrum pectinatum (Labill.) A.Löve	Comb Wheat Grass				√					H
Australopyrum retrofractum (Vickery) A.Löve	Comb Wheat Grass	√								H
Australopyrum velutinum (Nees) B.K.Simon	Mountain Wheat Grass				√	√	√			H

Austrostipa blackii (C.E.Hubb.) S.W.L.Jacobs & J.Everett	Crested Spear-grass		√						J
Austrostipa densiflora (Hughes) S.W.L.Jacobs & J.Everett	Foxtail Spear-grass	√							W
Austrostipa nivicola (J.H.Willis) S.W.L.Jacobs & J.Everett	Alpine Spear-grass					√			H
Austrostipa nodosa (S.T.Blake) S.W.L.Jacobs & J.Everett	Knotty Speargrass	√							W
Austrostipa pubescens (R.Br.) S.W.L.Jacobs & J.Everett					√				H
Austrostipa rudis (Spreng.) S.W.L.Jacobs & J.Everett			√						J
Austrostipa scabra var. *falcata* (Hughes) S.W.L.Jacobs & J.Everett		√	√						H
* *Avena barbata* Pott ex Link	Bearded Oats	√	√	√				Nat	H
* *Avena sativa* L.	Oats		√					Nat	M
Bothriochloa macra (Steud.) S.T.Blake.	Red Grass	√	√	√					C
* *Briza maxima* L.	Quaking Grass	√	√					Nat	M
* *Briza minor* L.	Shivery Grass	√	√					Nat	H
* *Bromus brevis* Steud.		√						Inv1	J
* *Bromus catharticus* Vahl	Prairie Grass	√			√			Nat	H
* *Bromus diandrus* Roth	Great Brome	√						Nat	H
* *Bromus hordeaceus* L.	Soft Brome					√		Nat	H
* *Bromus inermis* Leyss.	Awnless Brome	√						Inv1	H
* *Bromus madritensis* L.	Madrid Brome	√						Unknown	H
* *Bromus racemosus* L.	Smooth Brome	√						Inv1	J
* *Bromus rubens* L.	Red Brome	√	√	√				Nat	H
* *Bromus sterilis* L.	Sterile Brome							Unknown	MC
* *Bromus tectorum* L.	Drooping Brome			√	√			Inv1	H
Chionochloa frigida (Vickery) Conert	Robust Wallaby Grass				√		√		H
Chloris truncata R.Br.	Windmill Grass		√						M
Cymbopogon refractus (R.Br.) A.Camus	Barbed Wire Grass	√	√						H
Cynodon dactylon (L.) Pers.	Couch	√	√					Nat	H
* *Cynosurus echinatus* L.	Rough Dogs Tail	√	√	√				Nat	H
* *Dactylis glomerata* L.	Cocksfoot	√	√	√	√	√	√	Nat	H
Deschampsia cespitosa (L.) P.Beauv.	Tufted Hairgrass					√	√		H
* *Desmazeria rigida* (L.) Tutin	Annual Beardgrass	√						Inv1	J
Deyeuxia affinis M.Gray	Allied Bent-grass					√	√		H
Deyeuxia brachyathera (Stapf) Vickery	Short Bent-grass			√					H
Deyeuxia carinata Vickery	Keeled Bent-grass					√	√		H
Deyeuxia crassiuscula Vickery	Thick Bent-grass				√	√	√		H
Deyeuxia frigida F.Muell. ex Benth.	Bent-grass		√	√					H
Deyeuxia gunniana (Nees) Benth.						√			W
Deyeuxia innominata D.I.Morris						√			H
Deyeuxia microseta Vickery			√						G
Deyeuxia monticola (Roem. & Schult.) Vickery				√	√	√	√		H
Deyeuxia quadriseta (Labill.) Benth.	Bent-grass			√	√				H
Deyeuxia rodwayi Vickery			√	√					H
Deyeuxia scaberula Vickery		√	√	√					H
Dichanthium sericeum (R.Br.) A.Camus subsp. *sericeum*	Queensland Bluegrass	√	√						H
Dichelachne crinita (L.f.) Hook.f.	Longhair Plumegrass		√	√		√			H
Dichelachne hirtella N.G.Walsh	Plumegrass		√	√					H

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Dichelachne inaequiglumis (Hack. ex Cheeseman) Edgar & Connor			√	√						H
Dichelachne micrantha (Cav.) Domin	Shorthair Plumegrass	√	√	√						H
Dichelachne parva B.K.Simon				√						J
Dichelachne rara (R.Br.) Vickery			√	√		√				H
Dichelachne sieberiana Trin. & Rupr.				√						M
* *Digitaria sanguinalis* (L.) Scop.	Summer Grass		√	√					Nat	M
Echinopogon caespitosus C.E.Hubb. var. *caespitosus*	Tufted Hedgehog Grass		√							H
Echinopogon cheelii C.E.Hubb.	Long-flowered Hedgehog Grass		√							H
Echinopogon ovatus (G. Forst.) P.Beauv.	Forest Hedgehog Grass	√	√	√						H
* *Ehrharta erecta* Lam.	Panic Veldtgrass	√							Inv2	H
* *Ehrharta longiflora* Sm.	Annual Veldtgrass	√							Inv2	H
* *Eleusine tristachya* (Lam.) Lam.	Goose Grass			√					Nat	M
Elymus scaber (R.Br.) A.Love	Common Wheatgrass	√	√	√	√	√				H
* *Elytrigia repens* (L.) Desv. ex Nevski	English Couch			√					Unknown	W
Enneapogon nigricans (R.Br.) P.Beauv.	Niggerheads	√	√							W
Eragrostis brownii (Kunth) Nees	Brown's Lovegrass					√				W
* *Eragrostis curvula* (Schrad.) Nees	African Love Grass		√	√	√				Nat	M
Eragrostis parviflora (R.Br.) Trin	Weeping Lovegrass	√								AC
* *Eragrostis pilosa* (L.) P.Beauv.	Soft Lovegrass		√						Nat	M
Festuca asperula Vickery	Graceful Fescue			√	√	√				H
* *Festuca arundinacea* Schreb.	Tall Fescue			√	√				Nat	M
Festuca muelleri Vickery	Alpine Fescue					√				H
* *Festuca nigrescens* Lam.	Chewings Fescue			√	√				Inv2	H
* *Festuca pratensis* Huds.	Meadow Fescue			√					Nat	H
* *Festuca rubra* L.	Red Fescue					√	√		Inv2	H
* *Glyceria maxima* (Hartm.) Holmb.	Reed Sweetgrass					√			Inv1	H
Hemarthria uncinata R.Br.	Matgrass	√	√							H
Hierochloe redolens J. (Vahl) R.Br. ex Roem. & Schult.	Sweet Holy-grass					√	√			H
Hierochloe submutica F.Muell.	Alpine Holy-grass				√	√	√			H
* *Holcus lanatus* L.	Yorkshire Fog	√	√	√	√	√			Inv4	H
Hookerochloa eriopoda (Vickery) S.W.L.Jacobs	Snow Fescue		√	√	√					H
Hookerochloa hookeriana (F.Muell. ex Hook.f.) E.B.Alexeev	Hookers Fescue					√				H
* *Hordeum glaucum* Steud.	Northern Barley Grass						√		Cas	H
* *Hordeum leporinum* Link	Barley Grass	√	√						Unknown	W
Lachnagrostis aemula (R.Br.) Trin.	Tumbling Blown-grass		√	√		√				H
Lachnagrostis filiformis (G.Forst.) Trin.	Blowngrass	√	√	√		√				H
Lachnagrostis meionectes (Vickery) S.W.L.Jacobs	Alpine Blown-grass					√	√			H
* *Lolium multiflorum* Lam.	Italian Ryegrass			√					Unknown	W

* *Lolium perenne* L.	Perennial Ryegrass	√	√	√	√	√	√	Nat	H
* *Lolium rigidum* Gaudin	Wimmera Ryegrass			√				Unknown	W
Microlaena stipoides (Labill.) R.Br. var. *stipoides*	Meadow Rice-grass	√	√	√		√			H
* *Nassella trichotoma* (Nees) Hack. ex Arechav	Serrated Tussock	√	√					Unknown	W
Panicum effusum R.Br.	Hairy Panic	√	√						H
Paspalidium criniforme S.T.Blake	Panic Veldtgrass	√							J
Paspalidium gracile (R.Br.) Hughes	Fine Panic	√							H
* *Paspalum dilatatum* Poir.	Paspalum	√						Nat	H
Paspalum distichum L.	Water Couch								H
Pentapogon quadrifidus (Labill.) Baill.	Fiveawn Speargrass		√	√					H
* *Pentaschistis airoides* (Nees) Stapf	False Hairgrass		√					Nat	M
* *Phalaris aquatica* L.	Phalaris	√	√					Nat	H
* *Phalaris arundinacea* L.	Reed Canary Grass					√		Inv1	H
* *Phleum pratense* L.	Timothy				√		√	Nat	H
Phragmites australis (Cav.) Trin. ex Steud.	Common Reed	√	√						Atlas
* *Poa annua* L.	Winter Grass						√	Nat	H
Poa clivicola Vickery	Fine-leaved Snowgrass					√			H
* *Poa compressa* L.	Canada Bluegrass					√		Nat	H
Poa costiniana Vickery	Prickly Snowgrass			√	√	√	√		H
Poa ensiformis Vickery	Purple-sheathed Tussock-grass		√	√	√	√	√		H
Poa fawcettiae Vickery	Smooth Blue Snowgrass				√	√	√		H
Poa helmsii Vickery	Broad-leaved Snowgrass		√	√	√	√			H
Poa hiemata Vickery	Soft Snowgrass				√	√	√		H
Poa hookeri Vickery	Hooker's Tussock-grass					√			H
Poa induta Vickery					√				H
Poa labillardierei Steud. var. *labillardierei*	Tussock	√	√	√		√			H
Poa orthoclada N.G.Walsh	Avon Tussock-grass		√						H
Poa petrophila Vickery	Rock Tussock-grass					√			H
Poa phillipsiana Vickery	Blue Snowgrass			√	√	√			H
* *Poa pratensis* L.	Kentucky Bluegrass					√	√	Inv2	H
Poa sieberiana Spreng. var. *sieberiana*	Snowgrass	√	√	√	√	√			H
Poa sieberiana var. *cyanophylla* Vickery	Blue-leaf Tussock-grass		√	√	√	√			H
Poa sieberiana var. *hirtella* Vickery			√	√					H
Poa tenera F.Muell. ex Hook.f.	Slender Tussock-grass		√						H
* *Polypogon monspeliensis* (L.) Desf.	Annual Beardgrass	√						Inv2	H
* *Rostraria cristata* (L.) Tzvelev	Annual Catstail	√						Unknown	H
Rytidosperma alpicola (Vickery) Connor & Edgar	Alpine Grass						√		H
Rytidosperma australe (Petrie) Clayton & Renvoize ex Connor & Edgar	Southern Sheep-grass						√		H
Rytidosperma caespitosum (Gaudich.) Connor & Edgar	Ringed Wallaby-grass	√							W
Rytidosperma erianthum (Lindl.) Connor & Edgar		√		√		√			H
Rytidosperma fulvum (Vickery) A.M.Humphreys & H.P.Linder	Wallaby Grass	√	√						H
Rytidosperma laeve (Vickery) Connor & Edgar	Smooth Wallaby-grass	√	√			√			H
Rytidosperma longifolium (R.Br.) Connor & Edgar	Long-leaved Wallaby-grass	√							H
Rytidosperma monticola (Vickery) Connor & Edgar	Small-flower Wallaby-grass		√	√					J
Rytidosperma nivicola (Vickery) Connor & Edgar	Snow Wallaby-grass					√	√		H

Group / Family / Taxon	Common Name	Lower Snowy <700m	Tableland Forest 400–1000m	Montane Forest 1000m–1400m	Subalpine Snowgum 1400m–1800m	Subalpine / Montane Treeless <1800m	Alpine >1800m	Legal Status	Alien Status	Source
Rytidosperma nudiflorum (P. Morris) Connor & Edgar	Alpine Wallaby-grass					√	√			H
Rytidosperma oreophilum H.P.Linder & N.G.Walsh	Mountain Wallaby-grass					√				H
Rytidosperma pallidum (R.Br.) A.M.Humphreys & H.P.Linder	Silvertop Wallaby-grass	√	√	√	√					H
Rytidosperma penicillatum (Labill.) Connor & Edgar	Slender Wallaby-grass	√	√	√		√				H
Rytidosperma pilosum (R.Br.) Connor & Edgar	Smooth-flowered Wallaby-grass	√	√	√	√	√				H
Rytidosperma pumilum (Kirk) Clayton & Renvoize ex Connor & Edgar	Feldmark Grass						√	V (TSC)		H
Rytidosperma racemosum (R.Br.) Connor & Edgar			√							H
Rytidosperma setaceum (R.Br.) Connor & Edgar	Smallflower Wallaby-grass	√				√				H
Rytidosperma semiannulare (Labill.) Connor & Edgar	Tasmanian Wallaby-grass	√								H
Rytidosperma tenuius (Steud.) A.Hansen & Sunding	Short-awn Wallaby-grass			√						H
Rytidosperma vickeryae M.Gray & H.P.Linder	Perisher Wallaby-grass					√	√	E (TSC)		H
Saxipoa saxicola (R.Br.) Soreng, L.J.Gillespie & S.W.L.Jacobs	Rock Poa					√	√			H
* *Secale cereale* L.	Cereal Rye			√					Cas	H
* *Setaria parviflora* (Poir.) Kerguelen		√	√	√					Nat	M
* *Sporobolus africanus* (Poir.) Robyns & Tournay	Parramatta Grass		√						Nat	M
Themeda australis (R.Br.) Stapf	Kangaroo Grass	√	√	√		√				H
Trisetum spicatum subsp. *australiense* Hulten ex Veldkamp	Bristle Grass					√	√			H
* *Triticum aestivum* L.	Common Wheat		√						Cas	M
* *Vulpia bromoides* (L.) Gray	Squirrel Tail Fescue	√		√		√			Inv2	H
* *Vulpia muralis* (Kunth) Nees	Wall Fescue	√	√						Nat	H
* *Vulpia myuros* (L.) C.C.Gmel.	Rats Tail Fescue	√	√						Nat	H
POTAMOGETONACEAE										
Potamogeton cheesemanii A.Benn.	Pondweed					√				H
Potamogeton ochreatus Raoul	Blunt Pondweed			√	√					H
Potamogeton tricarinatus auct. non F.Muell. & A.Benn. ex A.Benn.	Floating Pondweed			√						H
RESTIONACEAE										
Baloskion australe (R.Br.) B.G. Briggs & L.A.S. Johnson				√	√	√				H
Empodisma minus (Hook.f.) L.A.S.Johnson & D.F.Cutler	Spreading Rope-rush			√	√	√	√			H
XANTHORRHOEACEAE										
Xanthorrhoea glauca subsp. *angustifolia* D.J.Bedford	Grass-tree	√	√							H

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An evaluation of two management options to restore species diversity of Eastern Suburbs Banksia Scrub at North Head, Sydney

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Abstract: Eastern Suburbs Banksia Scrub (ESBS) is a listed Endangered Ecological Community that becomes senescent and loses species diversity in its plant cover in the long-term absence of fire. However, the reintroduction of fire into remnant vegetation within urban areas presents management challenges and selective thinning is sometimes presented as an alternative management option. This project sought to evaluate fire and selective thinning of dominant species as tools for reinvigorating senescent ESBS.

Two peri-urban ESBS sites at North Head, Sydney, New South Wales, scheduled for hazard reduction burns to protect assets, were surveyed for their floristic attributes. Surveys were carried out in 7 x 7 metre quadrats, one third of which were fenced after fire to assess predation by herbivores. Similar quadrats were established on adjoining unburnt sites from which dominant species were removed through selective thinning.

Twelve months after treatment (and to a lesser extent at 6 months) burned ESBS displayed greater vigour and diversity than did thinned sites. Burned ESBS had more native plants, greater plant cover, more native species, greater species diversity and fewer weeds than did thinned ESBS. Burned and thinned ESBS sites had significantly low overlap in native species mix. Areas that had been fenced after fire had "superior" attributes to those that had not been fenced. There was nearly complete overlap of species between fenced and unfenced ESBS subjected to fire.

The results suggest that fire can be used advantageously to rejuvenate this type of heath and that this method produces superior results to thinning, but with a different species mix. These advantages accrue with time. The results of either method would be greatly inferior were attempts not made to control predation by exotic herbivores such as rabbits.

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Introduction

In 2012–13 the North Head Sanctuary Foundation (NHSF) in partnership with the Australian Wildlife Conservancy (AWC), conducted a comparative study of the use of fire and selective thinning as tools for the restoration of senescent Eastern Suburbs Banksia Scrub (ESBS) at North Head, Sydney. The name Eastern Suburbs Banksia Scrub, first used by Benson & Howell (1990) for vegetation on deep sands perched on sandstone in the south-eastern suburbs between Sydney Harbour and Botany Bay, is now used more broadly to include similar vegetation elsewhere on Sydney's eastern coast (Department of the Environment 2014).

ESBS is an open to closed heath found on the sand mantles which perch on Sydney's sandstone headlands (NSW National Parks and Wildlife Service 2004). It is a form of Coastal Sand Mantle Heath, (NSW Office of Environment

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and Heritage and Sydney Metropolitan Catchment Management Authority 2013) characterised by its highly podsolised soils derived from aeolian sand and by its heath community. A total of some 173 species of native plants have been recorded for Sand Mantle Heath. Two-thirds of these species are also found in ESBS; 54 of which are used to define ESBS (Department of the Environment 2014).

The vegetation was first noted by Joseph Banks in 1770 when he and Solander collected the first plant specimens at Botany Bay on Cook's *Endeavour* voyage (Banks 1963). At that time ESBS probably covered about 5,300ha (NSW National Parks and Wildlife Service 2004), but has now been largely destroyed by the suburban growth of Sydney. Substantial remnants of ESBS still occur at North Head, which contains an estimated 69ha of the remaining 146ha in Sydney. ESBS is an endangered ecological community, listed both nationally within the *Environment Protection and Biodiversity Conservation Act* 1999 and at state level within the *NSW Threatened Species Conservation Act* 1995 (Department of the Environment 2014; NSW National Parks and Wildlife Service 2004) .

Fire was an important tool used by Aboriginal people in coastal scrub communities (Wilson 1999) and was first recorded in the ESBS at North Head in 1788, when Bradley, Hunter and Worgan documented such a fire (Bradley 1969; Hunter 2009; Worgan 1978). A survey of pre-European fire-management practices for Sydney bushland can be found in McLoughlin (1998).

ESBS is an open, rich and diverse ecological community in the first few years after fire, when it is has been referred to as being *vigorous* by Skelton et al. (2003). With time the canopy closes, species richness and diversity in the standing vegetation decreases, and the community becomes dominated by a few large shrub species including *Leptospermum laevigatum*, *Banksia ericifolia* and *Monotoca elliptica*. Skelton et al. (2003) refer to this closed heath as *senescent*, its standing vegetation being less diverse than younger, more vigorous ESBS. The senescent state has been regarded as inferior both aesthetically and botanically by some (Department of Environment and Climate Change NSW 2009), but this inference neglects the fact that ESBS may have many post-fire states, and that although some species may not be in the plant cover at all times, they may still exist as seedbank propagules in the soil (Keith 1996; Keith et al. 2002; Keith and Tozer 2012).

Fire has been shown to both open the canopy and promote seeding and regeneration (Keith 1995; Keith et al. 2002; Keith and Tozer 2012), whereas thinning opens the canopy without the other beneficial effects of raised temperature and smoke on seed release and germination (Bradstock 1991; Dixon et al. 1995). For this reason fire is preferred as a regenerative tool. The preferred fire interval for ESBS is probably 8–30 years (Clemens and Franklin 1980; Clark and McLoughlin 1986; Morrison and Cary 1995; Kenny et al. 2004). However, best practice management guidelines recommend patchwork fires every 10–15 years (Department of Environment and Climate Change NSW 2009). The challenges in using fire close to densely settled urban areas are numerous and many bushland areas remain unburned beyond ecologically-preferred intervals (Cary et al. 2003; Jurskis et al. 2003; Driscoll et al. 2010;).

This project was designed to inform ecological management of ESBS across different land tenures by exploring the relative regenerative benefits of planned fire *versus* selective thinning. Protection from post-regenerative grazing by rabbits and other herbivores was an important management consideration.

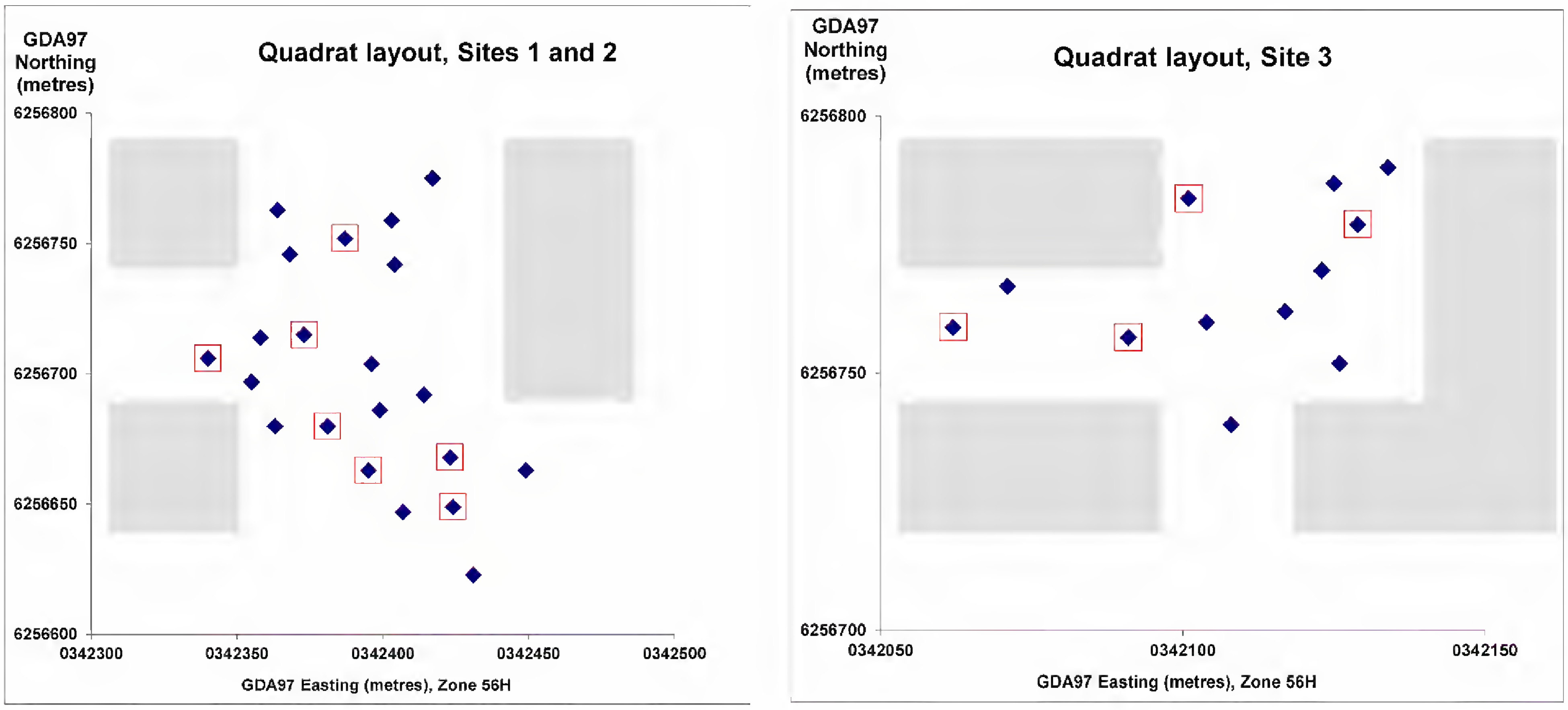


Fig 1 Layout of quadrats within burn sites. Each marker represents the south-west corner of a survey quadrat. Markers with surrounding squares indicate quadrats with fences.

Methods

We took advantage of two long-scheduled hazard reduction burns planned for three sites on North Head by the regional Bush Fire Management Committee. The burn sites were on Sydney Harbour Federation Trust land at North Fort and near the Third Quarantine Cemetery, but NPWS (as a designated fire agency) assisted with the burns (lat/long of the burn sites: S33° 49.058' E151° 17.827' and S33° 49.054' E151° 17.632'). As for all such burns, timing critically depended on the fire management personnel and resources available when the burns could be safely and effectively completed.

Burns were conducted on 6 September 2012; the areas burned totalled 1.3 ha and 0.7 ha. Slope within each site varied from flat to about 10%, and they were generally south facing sites with a mantle of aeolian sand.

Before the fires, a total of 37, 7x7 metre quadrats were allocated by a randomisation process across fire sites (31 quadrats) and thinning sites (5 quadrats) (one quadrat within the scheduled burn area did not burn and was not included in data analysis). Within the central 5x5 m core of each quadrat, four 1 x 1 m plots were selected randomly. Quadrat and plot corners were marked with aluminium tags (see Figure 1 for treatment layout).

Immediately after burning or thinning, fences were established around 10 burned quadrats and all five thinned quadrats to prevent access by herbivores. The wire mesh and star-picket fence design included a pegged skirt to deter burrowing. Fences were designed by Nicholas Skelton (pers. comm.) and trialled successfully by NHSF prior to the project.

To minimise the extent of ESBS removal and disturbance it was decided to have fewer thinned quadrats and locate them on track-side areas immediately opposite the burn sites. The dominant overstorey of *Leptospermum laevigatum* and *Monotoca elliptica* was cut and removed with chainsaws, with as little other disturbance to the site as possible. The process sought to approximate vegetation removal consistent with alternative fire risk management practices. Removal of the dominant species resulted in a nearly 100% opening up of the previous canopy, with only a few low-growing species and *Leptospermum* seedlings remaining.

Plots were surveyed at six and 12 months post-treatment. After the fire and subsequent fencing, wide-angle photographs were taken from the top of the north-west corner post of each quadrat, looking east, south-east and south. Photo surveys were repeated quarterly. We also examined NearMap© aerial photographs of the area taken at approximately 2–monthly intervals in the 2009–2014 period, to aid interpretation of the progress of regeneration.

Plots were measured botanically six and 12 months after burning or thinning. For every plant in each 1–metre plot in each quadrat, the following attributes and measurements were recorded:

Species identification

Classification as "Native" or "Weed"

Whether the plant was a species listed as characteristic of ESBS in the Final Determination under the NSW *Threatened Species Act*

The fire response of the plant (if known)

Developmental stage (seedling, juvenile, mature)

Reproductive status when observed (flowering, seeding, etc.)

Height in cm

From the data means of plant counts, species counts, cover, and median plant height were calculated across plots for the Burned-unfenced, Burned-fenced, and Thinned-fenced

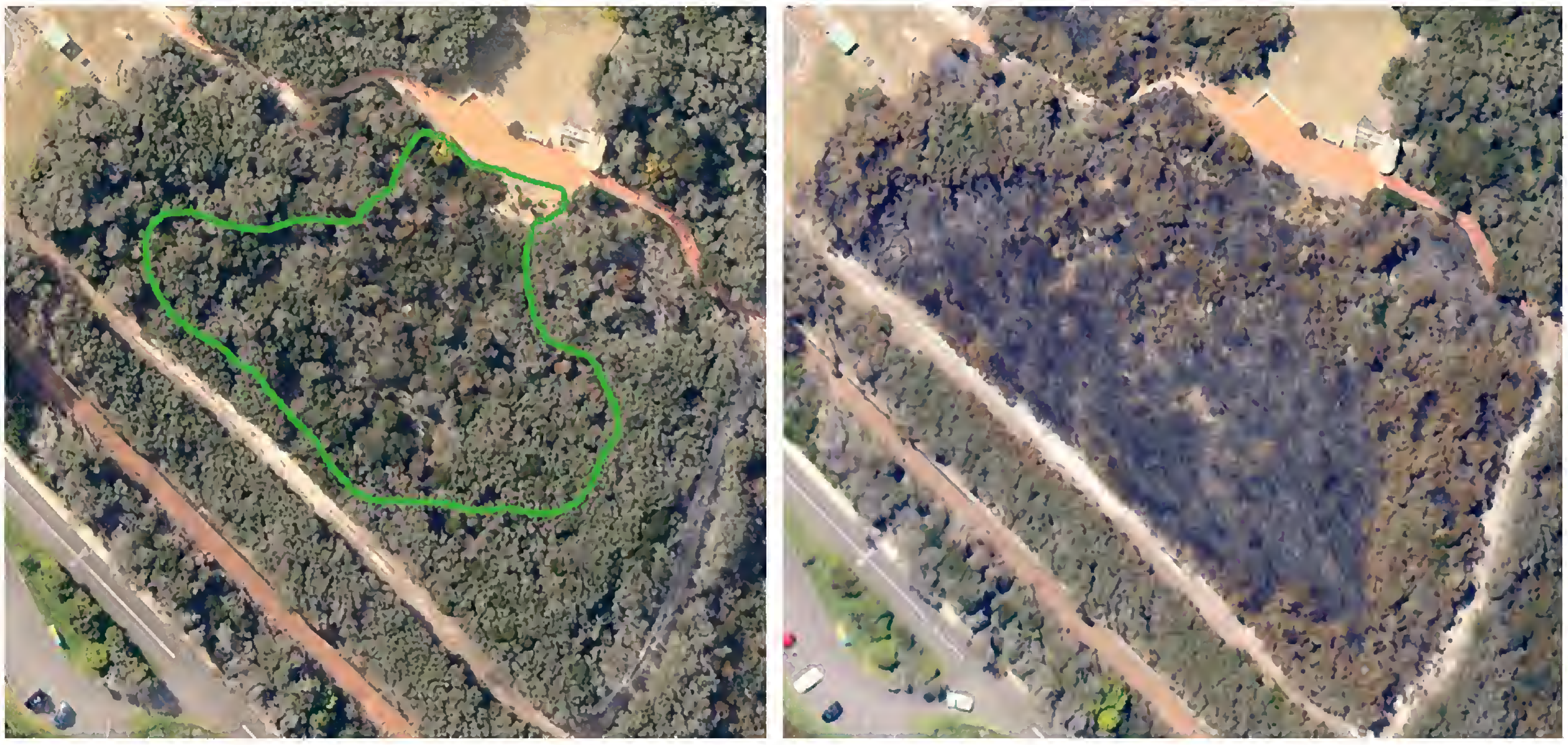


Fig 2. North Fort burn site one month before and two days after the fire. The "vigorous" core of ESBS is outlined in the pre-fire photograph. The patchiness of the fire is apparent. (Photos by NearMap©)

treatment comparisons. A Simpson diversity index (Gregorius and Gillet 2008) and a Morisita-Horn overlap index (Horn 1966) were used to measure the effects of treatments on the diversity and similarity of species present 12 months after treatment. Differences between mean values of parametric data were tested by Student's t-test. Differences among count data were tested by a χ^2 test. These tests had a power of 0.95. A permutation-driven Generalised Linear Model was used to test the significance of the Morisita-Horn overlap indices (Garratt and Steinhorst 1976; Nelder and Wedderburn 1972) from 0 (no overlap) to 1 (complete overlap). A probability level of $P \leq 0.05$ was accepted as "significant".

Results

Pre-treatment conditions and surveys

The greater part of the sites were densely vegetated, impeding comprehensive inspection. Under the vegetation layers, the ground surfaces comprised the following averages for "bare"– 8%; leaf litter– 16%; other plant litter– 75%; and rock– 2.4%. Some 104 different native species could be distinguished but only 57 could be assigned a definite species identification. There were 4% of plants at the seedling stage, 17% juvenile and 79% adult. Other than *Leptospermum laevigatum,* there were very few plants at all in the thinned sites, the ground cover of which was almost entirely leaf and twig litter.

Post-treatment conditions and surveys

Reports from fire crews (R. Strauch, pers. comm. 2013), on-ground visual inspection and oblique or vertical NearMap© aerial photography immediately post-fire, indicated the fire intensity varied widely across sites (Figure 2). Observation by fire professionals during the burn and the state of the remaining vegetation post-fire supported this assessment. One quadrat was completely unburned and was surveyed to act as a check against pre-burn status, but was not included in the post-fire analyses.

Except in the unburnt area, the post-fire surfaces were bare, consisting of on average 97% sand and 3% rock under the ash. It became apparent post-fire that the sites selected for thinning were not ideally matched with the burn areas, being somewhat flatter, with shallower sand and influenced by edge effects from the adjoining fire trails.

Table 1 Richness and abundance of plants within fenced plots six and 12 months after fire or thinning

		Burned (n=44)		**Thinned (n=20)**		
Time		**Mean ± S.E**			**Mean ± SE**	**Significance (P)**
A – 6 months	No. of ESBS plants per plot	3.7 ± 0.5			4.6 ± 0.7	NS
	No. of ESBS species per plot	1.5 ± 0.2			1.8 ± 0.2	NS
	No. of native plants per plot	11.6 ± 1.2			13.1 ± 1.5	NS
	No. of native species per plot	3.8 ± 0.3			4.9 ± 0.3	**<0.01**
	Plant cover (%)	23.1 ± 3.2			21.2 ± 4.3	NS
	Plant height (cm, Median)	3.0 ± 0.7			5.0 ± 1.3	NS
	Simpson Diversity	0.59 ± 0.03			0.73 ± 0.02	**<0.002**
	Morisita-Horn Overlap	Not calculated				
B – 12 months	No. of ESBS plants per plot		17.0 ± 1.9	6.2 ± 2.3		**< 0.01**
	No. of ESBS species per plot	3.3 ±0.2	2.2 ± 0.2		**<0.001**	
	No. of native plants per plot	36.5 ± 2.8	19.1 ± 2.4		**< 0.005**	
	No. of native species per plot	9.3 ± 0.4	7.4 ± 0.4		**<0.01**	
	Plant cover (%)	41.2 ± 4.4	25.3 ± 4.7		**<0.001**	
	Plant height(cm, Median)	12.0 ± 1.2	4.0 ± 0.8		**<0.05**	
	Simpson Diversity	0.75 ± 0.02	0.79 ± 0.03		NS	
	Morisita-Horn Overlap	0.36 ± 0.15			N/A	

Table 2 Species mix at six *versus* 12 months

	All native species			**ESBS Indicator Species**		
	Present in burned only	**Present in thinned only**	**Present in both**	**Present in burned only**	**Present in thinned only**	**Present in both**
6 months	61	17	16	24	10	7
12 months	76	10	34	24	9	7

As time since fire increased, the density of vegetation in many of the fenced plots increased, with the wattle species, *Acacia longifolia,* often dominant. Canopy cover changed from 0% to 100% in quadrats which had a high population of resprouting species such as *Banksia aemula, Lambertia formosa* and *Xanthorrhoea resinosa*. The latter species flowered within four months after the fire.

Six months after treatment (Table 1–A)

Although the fire sites were relatively small and the quadrats quite close together, data collected six months after fire showed considerable variation between quadrats. Mean canopy cover and median plant height were the same in thinned and burned plots. There was little difference in the number of plants (all or native) in fenced-burned versus fenced-thinned plots. The fenced-thinned plots were slightly more diverse. Almost twice as many weeds were found in the thinned plots compared with those in the burned plots. There were also differences in the mix of native species present in burned *vs* thinned plots.

Twelve months after treatment (Table 1–B)

By 12 months after treatment much more plant growth had occurred and cover, richness and abundance of plants were greater in burned areas than in thinned areas. The burned plots had more plants compared with thinned plots; more plant species and more native species. The diversity of species present in burned *versus* thinned plots (as measured by the Simpson's Index) were almost identical, but the Morisita-Horn coefficient for this comparison (0.36 ± 0.15)

Fig. 3. Difference in the distribution of native plant heights in fenced and unfenced plots

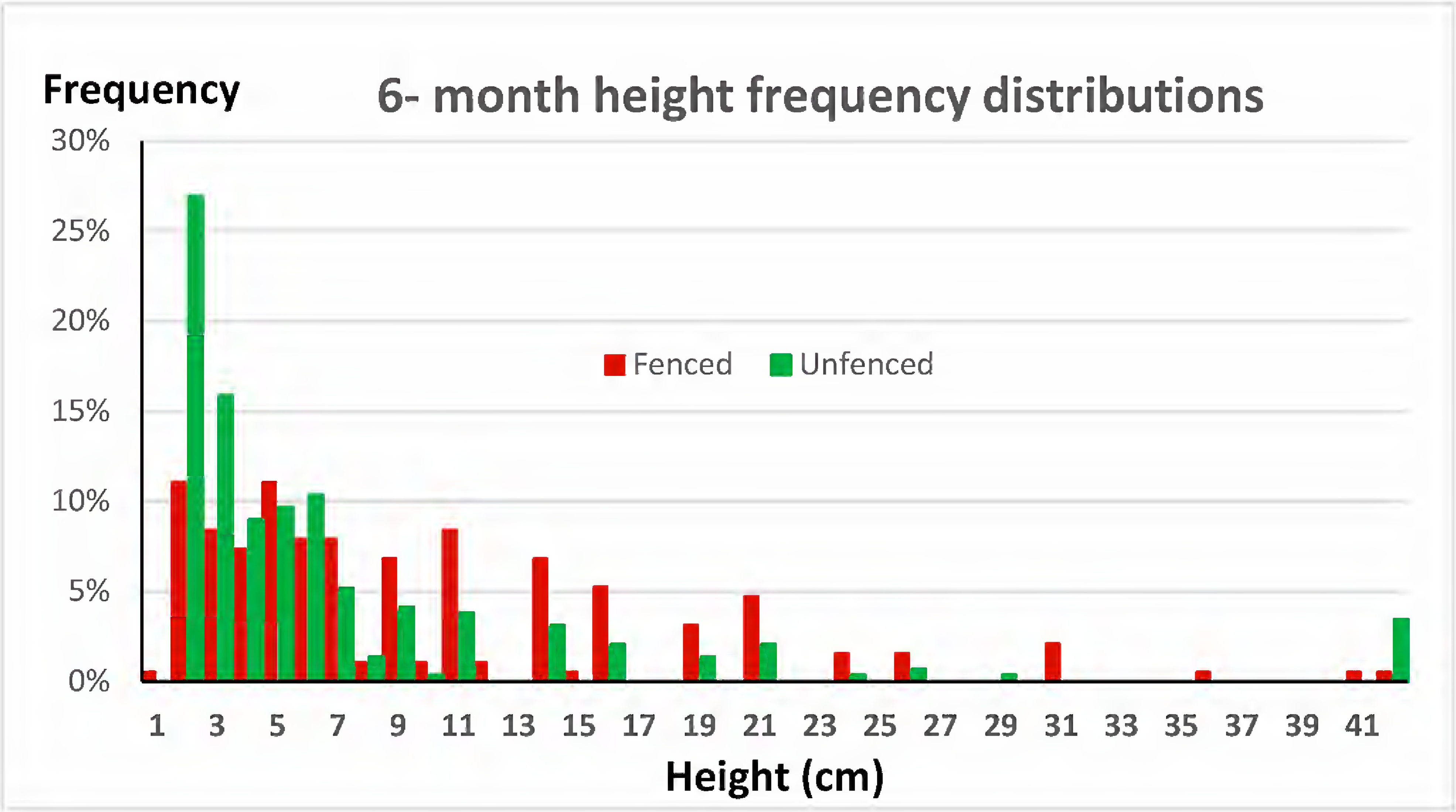


Table 3 Weed richness and abundance within fenced and unfenced plots at six and at 12 months after fire or thinning

		Burned/Unfenced (n=76) Mean ± S.E.	Burned/Fenced (n=44) Mean ± S.E.	Thinned/Fenced (n=20) Mean ± S.E.
A – months	No. of weeds/plot	0.8 ± 0.1	0.4 ± 0.2	1.7 ± 0.5*
	No. of weed species /plot	0.5 ± 0.1	0.3 ±0.1	1.1 ± 0.2*
B – 12 months	No. of weeds/plot	0.6 ± 0.1	1.4 ± 0.6	2.3 ± 0.8
	No. of weed species /plot	1.5 ± 0.1	0.5 ±0.2	0.9 ± 0.2*

*Significantly more weeds and weed species present in thinned plots (p<0.005) indicated a pronounced lack of overlap of species between burned-fenced and thinned-fenced plots. This lack of overlap is illustrated in Table 2, which shows the counts in the thinned and burned plots. The median height of plants in the burn plots at 12 months was greater than the height at 6 months. This difference was not seen with thinned plots.

Effects on ESBS species at 12 months

The indicator species identified for ESBS in national and state listings as an Endangered Ecological Community were used to assess success in reinvigorating the community. Twelve months after burning or thinning, the burned plots that were fenced had a greater diversity of ESBS indicator species per plot (mean 3.3 ± 0.2) than did thinned fenced plots (mean 2.2 ± 0.2). There was also a greater abundance of ESBS plants in the burned-fenced plots (17.0 ± 1.9) than in thinned-fenced plots (6.2 ± 2.3).

Impacts of disturbance on weeds

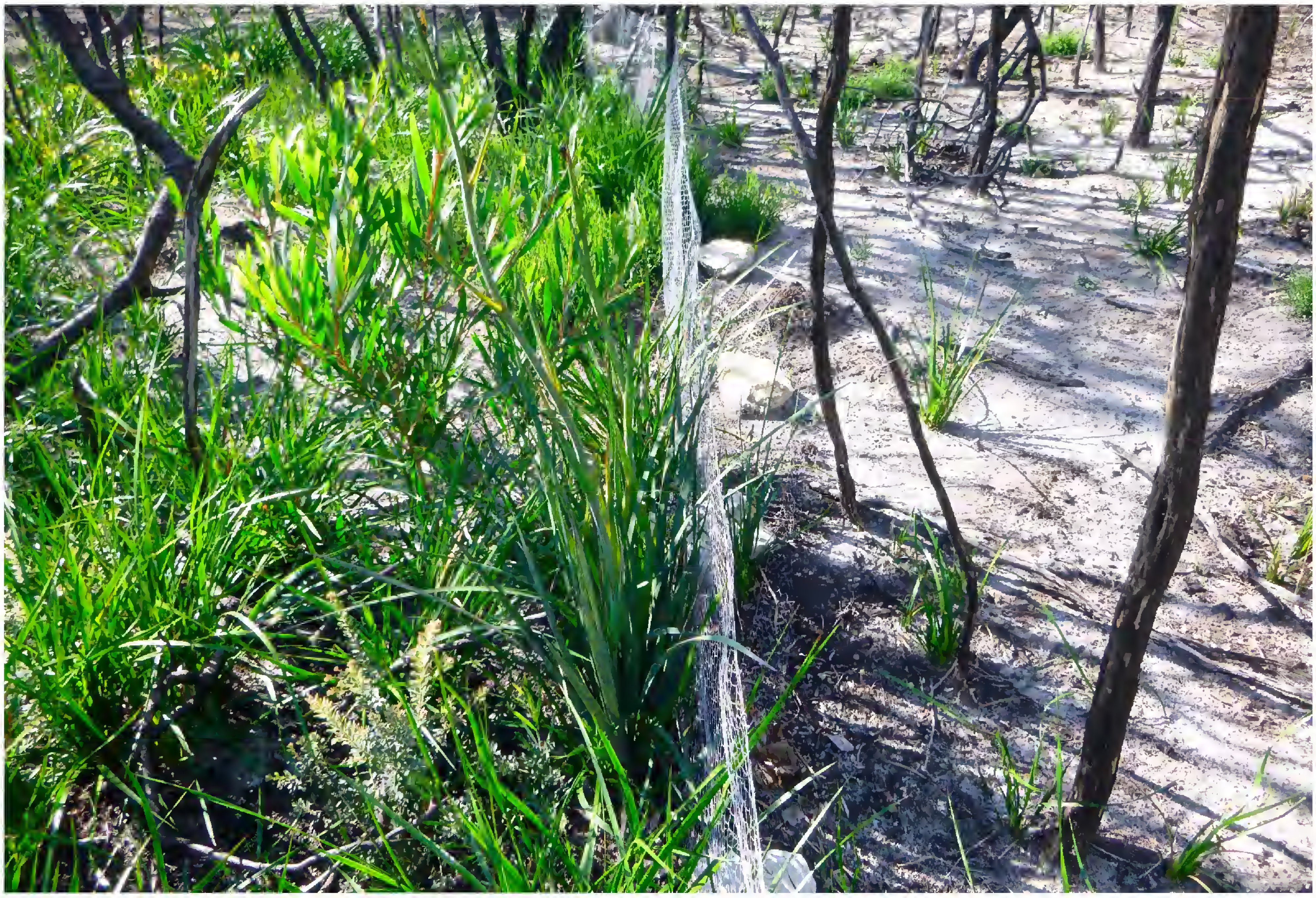
Compared with the native species present, there were relatively few weeds found in both burnt and thinned plots. At both six and 12 months after treatment the burn plots which had been fenced had fewer weeds and fewer weed species than did thinned plots (see Table 3). . Despite removal of identified weeds after assessment at six months, diversity and numbers of weed species were generally greater at 12 months than at six months.

Herbivore predation

The differences between fenced and unfenced quadrats which had been burned were striking (Table 4). At six months after burning, quadrats with rabbit exclusion fences appeared to be rabbit-free and had significantly more plants than the unfenced quadrats and a slightly greater number of native species. Plant cover was twice as high in fenced quadrats. The median height of native plants in the unfenced plots was slightly smaller (but not significantly so) than those in the fenced plots. However, the frequency distribution of heights at 6 months (Fig. 3) were highly skewed and indicated a far greater proportion of seedling, juvenile or eaten-down plants in the unfenced plots at 6 months. After twelve months this effect was less pronounced.

By 12 months after fire, the fenced plots still remained rabbit-free. Burned-fenced plots contained almost twice as many individual plants as did the burned-unfenced plots. The number of native plant species present in burned-fenced plots was 19% higher than in the burned-unfenced plots and plant cover was 160% higher. The species present in both types of quadrats were essentially identical.

Fig. 4 Typical illustration of fencing impacts on vegetation inside and outside the quadrat



Examination of plots indicated a few species showed exceptions to these observations. In particular, as might be anticipated from the work of Eldridge and Myers (2001) and Cooke and McPhee (2007) coarse, wiry species with fewer succulent leaves, such as *Lepidosperma laterale*, remained largely intact, whereas other more palatable species, especially *Acacia longifolia*, were visibly eaten down to just 1–2 cm in height, and were only very occasionally found in unfenced plots. Where these species were still present, their average heights were reduced by more than 50% in unfenced quadrats.

Discussion

Summary of findings

The present study was designed to compare the consequences of two fire management strategies on the regeneration of an Endangered Ecological Community, Eastern Suburbs Banksia Scrub. The results show that there was a greater increase in floristic richness in the plant cover of burned quadrats than in that of unburned but thinned quadrats, in which cover of the dominant species had been removed by selective thinning instead of burning. There was no significant difference in the Simpson Diversity Index between these two treatments at 12 months, although there was at six months. However the Morisita Overlap Index indicated a highly significant lack of overlap, a result of the two treatments affecting emergence of different species in different ways. These results also support the proposition that although plant cover of long unburnt ESBS may be species poor above-ground, species diversity is maintained in the soil seed bank.

Fire Intensity is recognised to influence species abundance in Sydney area heaths (Morrison 2002) but in this present study there were no consistent differences between areas where fire was judged to have been intense and those where fire was less intense. This observation is consistent with Morrison's finding (Morrison 2002; Morrison and Renwick 2000) that variations in fire intensity account for only approximately 10% of the floristic variation in a post-fire community.

As the results at six and 12 months after treatment demonstrate, time is needed for the impacts of a burn in ESBS to become apparent. A long period of relatively low rainfall immediately following the early September 2012 burn may have been an important factor in this delay but results with other ecological communities suggest that 3–5 years or more are needed for many vegetation communities to recover fully from fire (Pickup et al. 2013).

One of the strongest messages to emerge from this project is the importance of protecting recently burned or cleared areas from predation by rabbits and other herbivores. Plots in the fenced quadrats had more native plants and fewer weeds than plots in unfenced quadrats. This is supported by other research that has shown that predators not only eat native plants, they also spread weeds (Leigh et al. 1987). Cooke (1981) showed that in South Australia a rabbit density of one or two animals per hectare was sufficient to eliminate seedling emergence of some species and severely inhibit many others. From surveys currently underway on North Head, we estimate the rabbit population to be about five per hectare. Attempts at ecological restoration in ESBS without a mechanism to prevent rabbit predation may well be wasted effort and a major rabbit reduction program should be conducted in the period leading up to a burn. However, rabbit eradication is a labour- and cost-intensive task and, in the absence of full eradication, beneficial results may not endure. In the face of uncertainty as to when a controlled burn will actually take place and unpredictability of achieving appropriate burn conditions, other measures such as erection of an effective exclusion fence around the fire area immediately after a burn should be considered for all ecologically sensitive sites.

Context of the findings

Our findings need to be placed in the context of the ESBS community, the reported history of fire management by Indigenous people and two centuries of European impact

Table 4 Richness and abundance of plants within fenced and unfenced burned plots six months and 12 months after burning

	Fenced (n==44)	**Unfenced(n==76)**		
		Mean ± S.E.	**Mean ± S.E.**	**Significance P**
A – **6 months**	No. of plants per plot	14.4 ± 1.2	9.4 ± 0.8	<0.005
	No. of native plants per plot	11.6 ± 1.2	9.3 ± 0.8	NS
	No. of species per plot	4.8 ± 0.3	4.1 ± 0.2	NS
	No. of native species per plot	3.8 ± 0.3	.0 ± 0.2	NS
	Cover (per cent)	23.1 ± 3.2	12.2 ± 3.2	<0.02
	Height (median)	3.0 ± 0.7	2.0 ± 0.4	NS
B – 12 months	No. of plants per plot	37.9 ± 3.0	20.6 ± 1.3	< 0.001
	No. of native plants per plot	36.5 ± 2.8	20.0 ± 1.3	< 0.005
	No. of species per plot	10.6 ± 0.4	8.0 ± 0.3	<0.005
	No. of native species per plot	9.3 ± 0.4	7.8 ± 0.3	<0.001
	Cover (per cent)	41.2 ± 4.4	15.7 ± 3.0	<0.001
	Height (median)	12.0 ± 1.2	6.0 ± 1.4	<0.005

including wild and managed fires (Jurkis et al. 2003; Jurkis and Underwood 2013).

The evolutionary history of ESBS communities of Sydney is unclear. The aeolian sand dunes on which ESBS grows are a defining feature for the community. In 1969 Langford-Smith and Thom observed that "although they have been fixed for a long time"… "the sand dunes which mantle the cliff tops" in many parts of the New South Wales coast have "not been satisfactorily accounted for". The sand is probably of Pleistocene origin and of similar age to the soils of the Shoalhaven region (Nott and Price 1991), and that which supports ecological communities closely related to ESBS further north, on Bombi and Mourawaring Moors on the Bouddi Peninsula (McRae 1990), on Wybung Headland (Benson 1986) and the coastal wallum vegetation of southeast Queensland. Its origin may be congruent with that of the Quaternary aeolian dune field sands of the Newnes Plateau (Hesse et al. 2003) in the Blue Mountains. Leaching by 9,000 years of rain has reduced the fertility to a very low level (Wheen and Johnson 1986).

Attempts to evaluate ESBS at North Head have a long history. The descriptions of ESBS at Botany Bay in 1770 by Joseph Banks (1768–1771) are limited but congruent with current definitions of ESBS (NSW National Parks and Wildlife Service 2004; Department of Environment 2014). Early descriptions of the North Head landscape are sketchy and somewhat contradictory. Describing a visit on 28 May 1788 Bradley (see 1969) describes "an easy walk" over "sandy ground between the top of the rocks, cover'd with a variety of brush wood & shrubs some of which have very pretty blossoms", while Worgan (see 1978) refers to ascent of "a steep Rocky Hill, thickly covered with Brush- Wood". Conrad Martens' paintings of North Head, done over 43 years from the same position in Balmoral show gradual change in vegetation patterns. Evidence contained in old documents, previous surveys and anecdotal reports point to a diversity of use and change across the site since the late 1800s associated with its major uses as quarantine area, military occupation and nature park (Dawbin Architects Pty Ltd 2008; Robertson and Hindmarsh P/L 2010; Turner et al. 1996).

In 1986 Horton and Benson (1986) conducted a comprehensive survey of the Sydney Harbour National Park land area on North Head and delineated the Specht vegetation types- see also Benson (2011). A later survey by Skelton et al. (2003) extended this classification to delineate "vigorous ESBS" from "senescent ESBS", with the latter having a plant cover of low species diversity and being dominated by *Leptospermum laevigatum.*

Floristic lists for North Head (in Keith 1988) indicate the total native species count is of the order of 490, making the headland very species-rich. Some 140 native species were identified within the 1–metre plots of the study area. Fifty of these are species indicative of ESBS. Fire responses are not known for all of the North Head species, but of the total species within the plots, 45 could be classified as predominantly "resprouters" and 30 as "seeders" (Driscoll et al. 2010).

The fire history of North Head, fragmentary through the 19th and early- to mid-20th century, has been pieced together from 1929 to 2014 by the authors, from multiple historical and aerial photographs. There have been at least 50 wildfires and five controlled fires, ranging in area from a few square metres to almost the whole of North Head. The most recent large scale hot fires affecting the study area appear to have been in 1930, 1936, 1937 and 1951.

ESBS is an ecological community shaped by fire, but the picture is not simple. It is generally considered that over periods of 30–50 years, in the absence of fire, ESBS becomes senescent (Skelton et al. 2003); the community becomes dominated by an overstorey mainly of *Leptospermum laevigatum, Monotoca elliptica* and *Banksia ericifolia* with little groundcover variety. In Victoria *Leptospermum laevigatum* has been recognised as a species that invades and ultimately dominates heath communities on dry sandy substrates (Burrell 1981, Bennett 1994) and may be capable of shading out other species and reducing the diversity of extant ESBS. Moxham et al. (2010) describe in some detail the invasions of woody native species into a coastal dune system in Victoria in a 30–year absence of fire, slashing and human habitation. Bennett (1994) reported that neither fire nor its absence is the primary cause of the spread of *Leptospermum laevigatum* but the absence of fire over periods of more than 30 years is a significant factor at North Head (NSW NPWS 2004). In the current study, by 12 months after treatment, *Leptospermum laevigatum* plant density in the thinned plots (most of which were seedlings) exceeded that of the burnt plots by more than 50:1.

On North Head, ESBS communities generally have a core of "vigorous" scrub surrounded by an annulus of *Leptospermum* dominated scrub (Fig. 2 left). This occurs even where the core and the annulus have identical fire histories. It is independent of the size of the parcel, which is generally delineated by roads, fire-trails or walking tracks. The reason for this pattern is not clear but it may be related to an edge effect of light and/or access-related disturbance. Analysis of aerial photographs over the period 1929 to 2014 supports the idea that prior removal of ESBS resulted in invasion or dominance by *Leptospermum laevigatum.* From the 1940s there was extensive mechanical reshaping of sand surfaces for military purposes and this probably increased the extent of the quick growing seedling colonisers, particularly *Leptospermum laevigatum* colonising inn the absence of fire, while destroying the lignotubers and rootstocks of the resprouter species such as *Banksia aemula.* The military use of the area probably meant that because of stored ammunitions etc. there was also a policy of avoiding fire.

Conclusions

The challenges in introducing managed fire into urban and peri-urban bushland areas in a safe manner and with scarce resources have constrained the use of fire for ecological management. These challenges may be acute for species and ecological communities already at risk of extinction. Alternatives to fire as a management option such as vegetation thinning are often proposed, with little evidence of their relative effectiveness. This report begins to fill that gap. While small in scale and budget, the project provides managers with guidance on **the relatively greater benefits of fire over thinning** as a tool for enhancing regeneration of senescent coastal scrub, while seeking to minimise the risks of wildfire. It also dramatically illustrates **the deleterious impact of herbivory by rabbits on young post-fire vegetation**. Importantly, the project also illustrated how community effort, supported by appropriate technical expertise, can enhance agency management of significant areas of urban bushland.

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Year-to-year variation in cone production in *Wollemia nobilis* (Wollemi Pine)

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Abstract: Seed production varies from year-to-year in most species. Factors influencing this variation can include pollination and dispersal mechanisms, seed predation and resource availability. Here we examine a long-term (12– year) photographic record of seed cone production for the Australian endemic conifer *Wollemia nobilis* (Araucariaceae). Coefficient of variation (a commonly used measure of variation in seed production) was low for the two trees analysed, compared with published values for other polycarpic plants. Nevertheless, cone production decreased with increasing spring minimum temperatures (during pollination) and increased with summer total rainfall (during cone initiation). Hence, *Wollemia nobilis* cone production was correlated with weather, in line with the resource-matching hypothesis. Impacts of variation in cone production on the *Wollemia nobilis* population are likely to be buffered by the shade-tolerant, slow-growing juvenile life stage of *Wollemia nobilis*.

Keywords: Araucariaceae, climate, masting, weather, Wollemi National Park.

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Introduction

Most woody plants that produce seed many times in their lifetime (polycarpic plants) show variation in seed production from year-to-year (Herrera et al. 1998). Mast seeding is one extreme, and is defined as seed production that is highly variable, with synchronous production of large seed crops (Janzen 1971, Silvertown 1980, Norton and Kelly 1988, Kelly 1994). However, the existence of masting has been a source of debate, because of the difficulty in defining each year as either mast or non-mast, and determining how many individuals must show similar variation in seed production to achieve synchronicity (Kelly 1994, Herrera et al. 1998).

Factors that promote increased variation in seed production are wind pollination and seed predation, while decreased variation can be affected by animal dispersal and pollination (Kelly and Sork 2002). For example, seed production in wind-pollinated species is more variable than in animal-pollinated species (Herrera et al. 1998). This is because a synchronous increase in pollen production in wind-pollinated plants increases the probability of pollination (the wind pollination hypothesis, Kelly 1994; Nilsson and Wastjung 1987; Smith et al. 1990; Kelly et al. 2001). Alternatively, species responding to seed predation produce large numbers of seeds in some years, so that seed predators are satiated, and more seeds survive. Low numbers of seeds

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are then produced in intervening years, so that seed predators are starved and hence predator populations decrease (Janzen 1971; Silvertown 1980). In contrast, species with animal-dispersed seeds typically show lower variability in seed production, as consistency in fruit production is maintained to support the population of the disperser animal (Janzen 1971, Herrera et al. 1998).

When these influences promoting high or low seed variation are absent, seed production will vary with environmental conditions (i.e., weather; Kelly 1994, Kelly and Sork 2002). The resource-matching hypothesis suggests that investment in reproduction (i.e., seed production in plants) is influenced by resource availability, which is influenced by the weather (Kelly 1994). Although resource matching is the simplest explanation for variation in seed production, it has been highlighted that the variation in weather is often not as great as the variation in seed production (Koenig et al 2003, Kelly and Sork 2002), suggesting complexity in this relationship and, or the influence of other factors.

Significant synchronicity in seed production is known to occur in members of the Araucariaceae family (Enright and Hill 1995, Sanguinetti and Kitzberger 2008, Souza et al. 2010, Rigg et al. 2010). Year-to-year variation in seed-bearing female strobili (hereafter 'cone' for brevity and simplicity) production of *Wollemia nobilis* (Wollemi Pine) family Araucariaceae, is not known. Yet, seed production is likely to be important in maintaining the population of slow-growing, shade-tolerant juvenile *Wollemia nobilis* plants that exist in the understorey below the mature *Wollemia nobilis* trees (Zimmer et al. 2014). *Wollemia nobilis* is of high conservation value and is a State- and Federally-listed threatened species (NSW Department of Environment and Conservation 2006). It was discovered only in 1994 and within 200 km of Sydney, Australia. *Wollemia nobilis* is a long-lived tree, and is wind-pollinated, producing male and female cones on one plant (i.e. monecious). Its seeds are generally dispersed by gravity, wind or water. Some dispersal by birds, which also feed on and destroy the seeds, may also occur. *Wollemia nobilis* seed viability is low, around 10% (Offord et al. 1999; low viability has been recorded for other Araucariaceae e.g. Enright et al. 1999, Kettle et al. 2008). Seedling germination and initial survival is also low, and new seedling emergence is variable (Zimmer et al. 2014). Collection of year-to-year seed (cf. cone) production data in this species is difficult due to the inherent problems of inaccessibility and rarity. Regardless, it has been suggested that the rate of viable seed production varies (Offord et al. 1999; although the observed viability rate is also likely to be influenced by the date of sampling).

Table 1. Timing of *Wollemia nobilis* cone development and growth.

Season	Lag (years)	Female cone	Male cone	Vegetative
Spring	–3			Growing
Summer	–2	Initiation	Initiation	
Autumn	–2			
Winter	–2			
Spring	–2	Pollination	Maturation	Growing
Summer	–1			
Autumn	–1			
Winter	–1			
Spring	–1	Fertilization		Growing
Summer	0			
Autumn	0	Seed fall		

In this study seed cone production was estimated using a series of annual photos to explore annual seed production in *Wollemia* and to explore the following questions-

How much does *Wollemia nobilis* cone production vary from year-to-year?

Is cone production correlated among individual *Wollemia nobilis* trees?

Is variation in *Wollemia nobilis* cone production correlated with weather, in particular temperature and rainfall?

Methods

Photography and data collection

High-resolution photos of mature *Wollemia nobilis* tree canopies (e.g. Figure 1) were taken from permanent photo points at Site 1 (Benson and Allen 2007). Photos were taken every year, from 2002 to 2014 (except 2007). Photography, in late summer/early autumn (February–March), was timed to capture cone maturation. New female cones can first be seen in summer (with the naked eye), around two years before maturation, they are pollinated the following spring, fertilized in spring one year after that, and mature late in the following summer (Table 1). In several years (2002, 2003, 2005) photographs were also taken in October. This allowed us to check mature female cone counts, as unfertilized cones are markedly smaller than fertilized cones. Photos were taken with different cameras as technology improved (i.e., from film to digital). To begin with, photographs were taken with a Linhof 4" x 5" view camera and a 150 mm lens, while the later photos were taken with an Olympus EM-5 camera.

From these high-resolution photos we counted mature female cones (including newly shattered cones) on two individual trees, Trees 1 and 19. These trees were chosen because they were closest to the photography point, and the only trees where clear identification of cones (and differentiation among individual trees) was possible. In addition, identification of individual trees was clear, whereas photos of other parts of the site had trees with overlapping crowns. The mature female cone counts (hereafter cone counts) from Trees 1 and 19 constitute an index of cone production, as only the facing side of the tree can be seen. The same area of each tree was counted in every year (i.e. the area hidden by foliage from other trees that had grown up by 2014 was removed from counts for previous years).

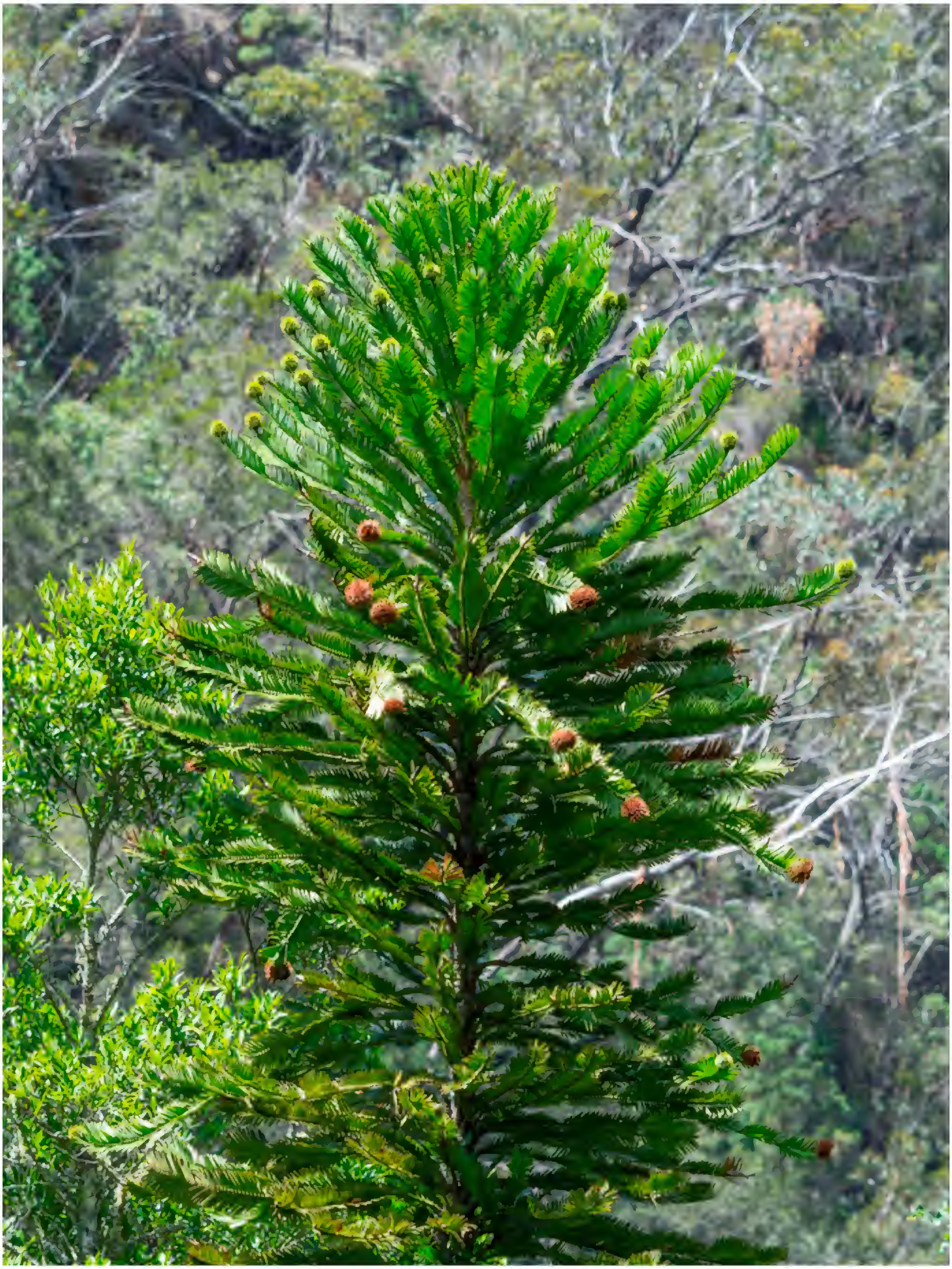

Fig. 1. Photograph of the top of Tree 19 in summer, showing mature female cones (mid-section; brown colour) and the immature next year's cohort (top section; green colour). Photo: Jaime Plaza.

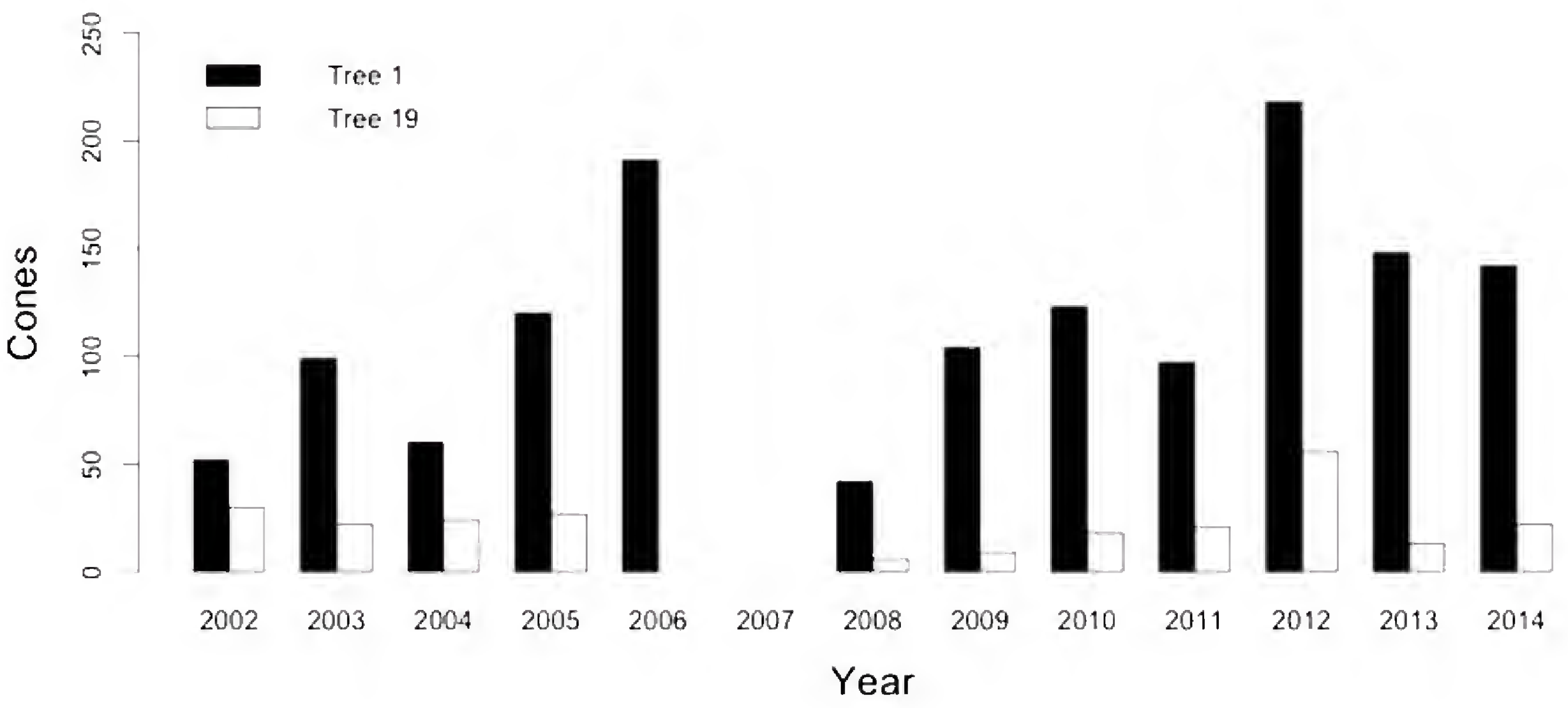

Fig. 2. Mature female cone production in Tree 1 and Tree 19 from 2002 to 2014. Photographs were taken in May 2002, March 2003, March 2004, March 2005, March 2006, January 2008, January 2009, January 2010, March 2011, March 2012, February 2013 and February 2014. There was no sampling in 2007 and no data for Tree 19 in 2006.

Statistical analyses

Correlation in cone counts between Tree 1 and Tree 19 was assessed using Spearman's rank tests. Coefficient of variation (CV) in cone counts for each tree was calculated as the standard deviation divided by the mean. CV is a commonly used measure of year-to-year variation in seed production (Silvertown 1980; Kelly 1994; Herrera et al. 1998). CV is useful as a simple indicator of year-to-year variation. It is independent of the mean (McArdle and Gaston 1995), and therefore tree/population size. Most commonly CV is calculated to assess population-level year-to-year variation in seed crop (i.e., mean and standard deviation of total population seed output, Herrera 1998). In our study, single tree CVs are being used to indicate population-level variability, and comparison of cone counts between these two trees is being used as an indicator for synchronicity. We acknowledge that our sample size is small; this is why our conclusions are tentative.

Spearman's rank tests were used to assess correlations between Tree 1 cone counts and weather. Tree 1 was selected for analysis because it had the longest data set, including two high cone count years. Cone count was correlated with weather factors for each season: (1) mean maximum temperature, (2) mean minimum temperature, (3) maximum temperature, (4) minimum temperature, (5) lowest maximum temperature (6) highest minimum temperature and (7) total rainfall. Seasons were summer (December – February), autumn (March – May), winter (June – August) and spring (September – November).

Cone development occurs over approximately two years (Table 1). Hence, the correlation between cone count and each weather factor was analysed for: the summer in which cone maturation occurred (summer$_0$; $n = 7$), the four seasons before cone maturation (season$_{-1}$; $n = 28$), the four seasons after initiation (season$_{-2}$; $n = 28$) and the spring immediately before cone initiation (spring $_{-3}$; $n = 7$). Because this was an exploratory study, multiple comparisons of the cone production data were made with the weather factors. For this reason, the probability of Type 1 errors (false positives) was increased, so P-values are not presented (all non-significant). Climate data were from Bureau of Meteorology (2014) from a weather station near the study site. Weather at the two sites is closely correlated (unpublished data). All analyses were completed using R (Version 3.03, R Core Team 2013).

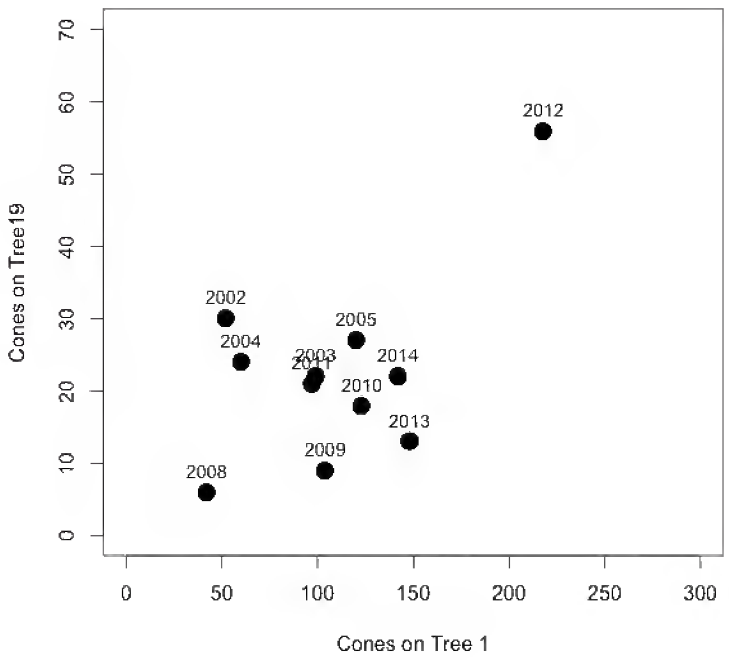

Fig. 3. Correlation between cone production in Tree 1 and Tree 19. Note axes scales differ.

Results

Cone counts varied from year-to-year and coefficients of variation were 0.45 and 0.58 for Tree 1 and Tree 19, respectively. Tree 1 cone count ranged from 42 to 218, while cone count for the smaller Tree 19 ranged from six to 56. The highest cone count for both trees was in 2012 (Figure 2), the second highest was in 2006 for Tree 1 (photos were not taken of Tree 19 in 2006). The correlation between year-to-year variation in cone count between the two trees was low (ρ = 0.164), although their lowest and highest cone count years were the same (Figure 3).

The strongest correlation between cone count and weather factors was with minimum temperature in spring$_{-2}$ (ρ = -0.76), while the second strongest correlation with temperature was with spring$_{-1}$ highest minimum temperature (ρ = 0.62). Hence, there were more cones when minimum temperatures were lower during pollination, and when minimum temperatures were higher during fertilization.

The highest correlation for rainfall was with summer$_{-2}$ rainfall (ρ = 0.67). When rainfall increased during this period (which includes cone initiation), so did the number of cones.

Discussion

Year-to-year variation in *Wollemia nobilis* cone production was low (CV = 0.45 and 0.58 for mature female cones on two trees) compared to other polycarpic trees (Kelly 1994, Herrera et al. 1998). Reviews indicate that most plants have coefficients of variation for seed production between 0.8 and 1.2 (Kelly 1994, review of 42 datasets; Herrera et al. 1998, review of 296 datasets, mean CV = 1.2). Variation in CV does not differ significantly between gymnosperms and angiosperms (Herrera et al. 1998). Coefficients of variation higher than two have been recorded, such as 2.12 for *Nothofagus solandri* in New Zealand (Kelly et al. 2001). Alternatively, CVs lower than 0.4 are probably under-reported (Kelly 1994).

There was some evidence for synchronicity in cone counts between the two *Wollemia nobilis* in this study: the trees shared highest and lowest cone production years, but cone counts in other years were poorly correlated. Causes of between-year correlation for individual trees, apart from size, may include the number and size of neighbours (Haymes and Fox 2012). Cone production was consistently higher in Tree 1, the larger of the two trees and the dominant tree at the site. In addition, we know that the number of viable seeds per *Wollemia nobilis* cone varies (Offord et al. 1999), but we do not know whether the numbers of viable seeds increase when the number of cones increases; this is an important limitation of our study. In our discussion of influences on cone production, we assume that increased cone production results in increased seed production. This is an informed assumption. An 18-year seed collection dataset for *Araucaria araucana* describing regional-scale, year-to-year synchronicity in seed production, showed higher seed numbers and viabilities in high cone production years (Sanguinetti and Kitzberger 2008). Notably, mean CV here was 1.16.

What causes variation in cone production in *Wollemia nobilis?* The most likely explanation is variation in resource availability, which is in turn influenced by weather (i.e. the resource-matching hypothesis). But the relationship between cone production and weather was not straightforward. As *Wollemia nobilis* growing season is in spring, a simple indicator of resource matching would have been strong correlations with temperature in spring before cone initiation (spring$_{-3}$), as temperature controls photosynthesis and growth. While this was not the case, there was a strong correlation with rainfall during cone initiation (summer$_{-2,}$ ρ = 0.67). Where rainfall increased, so did the number of cones. On the other hand, temperature during pollination (when male cones are maturing and female cones are becoming receptive) showed the strongest correlation of any weather factor (ρ = - 0.76).

Correlations with temperature during flower and cone initiation are usually attributed to temperature acting as a synchronizing cue, rather than directly influencing resource availability (Ashton et al. 1988, Norton and Kelly 1998, Schauber et al. 2002). The correlation between temperature during pollination and *Wollemia nobilis* cone production is difficult to explain as the cones were already initiated, and we do not have the data to quantify year-to-year variation in cone abortion. Increasing cone count with decreasing temperatures during pollination may indicate that a temperature-sensitive process is occurring at this time. Our conclusions about causes of variation in cone production are tentative because of our very small sample size.

Low variability in seed production fits with having a slow-growing, shade-tolerant bank of juveniles (as in *Wollemia nobilis*, Zimmer et al. 2014). Similar to species that maintain a soil seed bank (*sensu* Nathan and Muller-Landeau 2000), the influence of variability in seed production on the population is reduced in species that maintain a juvenile bank. A further benefit of having a juvenile bank is that these juveniles are available to take advantage of increased resource availability when it occurs (e.g., via gap formation). This is different to species that do not maintain a juvenile bank (or soil seed bank), and rely on increased seed to produce more seedlings in favourable conditions. Interestingly, the limited records of seedling germination of *Wollemia nobilis* do not show increased seedling numbers after high cone counts, supporting the idea that seed availability is not always the main factor limiting the establishment of new *Wollemia nobilis* seedlings. Specifically, the highest *Wollemia nobilis* germination from 2001–2005 was in 2005, more than double the number of new seedlings of the next highest year (Zimmer et al. 2014), whereas cone production in 2005 was only slightly above the mean. *Wollemia nobilis* seedling recruitment is likely to be limited at multiple stages, not only seed availability (including seed viability), but also seed dispersal, seedling survival, growth and establishment (Clark et al. 1998). For example, research indicates that temperature and water availability influence *Wollemia nobilis* germination (Offord and Meagher 2001), growth and survival (Offord 2011). Limiting factors may vary from year-to-year, with seed availability limiting in some years, and microsite availability in others (Eriksson and Ehrlen 1992). However, long-term changes to climate may be less able to be buffered by the juvenile bank.

Other factors that could influence variation in seed production are wind pollination and seed predation. We have observed an abundance of *Wollemia nobilis* pollen in the aerial environment during pollen release, and subsequently on cone scales under a light microscope (C. Offord and P. Meagher, pers. obs). No specific seed predators of *Wollemia nobilis* are known, but during the study by Offord et al. (1999) 25% of the seeds in seed traps were damaged by seed predators. Damage was attributed to animals, including insects (Offord et al. 1999). The high numbers of easily accessible seed in the nets may have attracted more predators than usual. Several seed-eating birds have been sighted near the *Wollemia nobilis* grove (S. Clarke, pers. obs). However, these birds are likely to forage widely, and their predation is unlikely to influence variability in seed production (Kelly et al. 2002).

Conclusion

Wollemia nobilis cone production shows low variability from year-to-year, and there was limited evidence for synchronicity between the two trees examined. Our results are tentative, because of this small sample size, but we found that cone production was most strongly correlated with summer$_{-2}$ rainfall during cone initiation, and minimum temperatures in spring$_{-2}$, during pollination. Availability of resources related to weather provides one explanation for variation in cone production. If cone production is influenced by weather, then future changes to climate, such as increased spring minimum temperatures, or decreased summer rainfall could negatively impact *Wollemia nobilis* cone production. The maintenance of a bank of juvenile *Wollemia nobilis* plants means that the impact of variation in seed input from year-to-year is reduced (compared with species reliant on annual germination to maintain a supply of recruits); however sustained changes to climate may have a greater effect.

Future research

This study has highlighted our knowledge gap around the relationship between *Wollemia nobilis* cone production and seed viability and we would like to raise the following questions for future research:

> Is there a correlation between seed cone production and viable seed production? The work of Offord et al. (1999) needs to be extended.
>
> Is variation in male cone production synchronous with variation in female cone production? A photographic record of cone production in October is required.
>
> Is variation in male cone production accompanied by variation in pollen viability?
>
> When does meristem initiation for *Wollemia nobilis* cones occur in the wild? If we knew exactly when cones were initiated we would be better able to target investigation of weather effects.
>
> Could seed production in *Wollemia nobilis* be ovule limited? Ovule limitation occurs when all ovules are fertilised, but there are too few zygotes to completely use available resources (Harder and Routley 2006).
>
> How common is self-fertilisation in *Wollemia nobilis*? Does selfing lead to fewer viable seeds? Or, is there differential development of self-fertilised to outcrossed embryos to maturity? If selfed seeds are less likely to be viable, this would promote among-species synchronicity in seed production.
>
> Is *Wollemia nobilis* pollen limited in the wild? Anecdotal observation suggests that pollen is abundant, but experimental work, especially around levels of pollen viability, is lacking.
>
> At what rate do *Wollemia nobilis* embryos and cones abort after initiation? Is this influenced by pollen availability and or successful pollination? And is pollination and fertilisation success affected by temperature?

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I saw a good deal of the country much more than any other collector
An assessment of the botanical collections of Eugene Fitzalan (1830–1911)

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Abstract: *I saw a good deal of the country much more than any other collector*[1]. Eugene [Fitzherbert Albini] Fitzalan (1830–1911) came to Australia from Ireland about 1849. His first significant appointment as a botanical collector was on the Queensland Government's expedition to investigate the estuary of the Burdekin River in 1860, commanded by Joseph W. Smith RN on the Schooner *Spitfire*. Fitzalan was engaged as a plant collector by Ferdinand Mueller, the Government Botanist for the Colony of Victoria. Following the Burdekin Expedition of 1860, Fitzalan became a pioneer settler in 1861, at the newly proclaimed township of Bowen (Port Denison) from where he undertook collecting excursions to Mount Dryander, Mount Elliot, Townsville, Cairns, Daintree River and Cooktown, whilst establishing and managing a seed and plant nursery business. He was a contemporary and/or collecting companion of F.M.Bailey, Charles Weldon Birch, Edward Bowman, John Dallachy, Amalie Dietrich, Stephen Johnson, Walter Hill, Frederick Kilner, L.G. Nugent and Walter Froggatt. Fitzalan moved to Cairns in 1886, and became active in the initial development of the Cairns Municipal Botanical Reserve, the site of the future heritage-listed Cairns Botanic Gardens. Fitzalan's collections number to about 2200 herbarium specimens. This number places him in the top five most productive collectors in Queensland for the 1860–1900 period. His specimens were initially dispatched to Ferdinand Mueller in Melbourne, and most are now conserved in the National Herbarium of Victoria [MEL]. A small number of specimens and duplicates are conserved in other Australian and international herbaria, including BM, BR, BRI, FI, G, HAL, K, NSW, U and W. About 90 of Fitzalan's collections are relevant to typification, and he is eponymously connected to at least 12 taxa, of which five are the currently used names. As well as examining Fitzalan's primary plant collecting activities, this work provides a broad biographical background and assesses his horticultural contributions.

Key words: Eugene Fitzalan, Mueller's collectors, Queensland early botany, historical plant records for Queensland

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Introduction

The period in Australian botanical research from the early 1850s through to the late 1890s has been termed the *Muellerian Era* (Barker & Barker 1990) on account of the dominance of Ferdinand Mueller's taxonomic work (Maroske 2014). Mueller, as Government Botanist for the Colony of Victoria, established an extensive network of plant collectors (Maroske 1993), and much of the botanical progress in the Australian colonies was initiated and encouraged by Mueller in collaboration with his collectors and fellow taxonomists (Home *et al.* 1998; Maroske & Vaughan 2014).

The 1860s marked the beginning of a rapid increase in botanical investigation in the newly declared colony of Queensland. Eugene [Fitzherbert Albini] Fitzalan (b. 12 July 1830, Londonderry, Ireland; d. 20 June 1911, South Brisbane) (Figure 1) was among the first plant collectors engaged by Mueller to venture into remote areas not yet settled by Europeans in the new colony. Through his botanical collections and horticultural endeavours, Fitzalan made a significant contribution to the advancement of studies into the colony's flora. Fitzalan collected about 2200 botanical specimens (AVH 2014) in Queensland between 1860 and 1896. About 90 of his specimens are important as type materials for new taxa that were thus described. He is eponymously involved in at least 12 taxa, of which five are the currently used names (Table 1; Figure 2) and his name is commemorated in a number of geographical features and landmarks (Table 2). Fitzalan undertook a number of significant expeditions and excursions (Table 3). Some of these were the first botanical ventures into those areas, such as the Burdekin Expedition [1860], Mount Elliot [1863, 1872], Mount Dryander [1869, 1872] and Daintree River [1875, 1876].

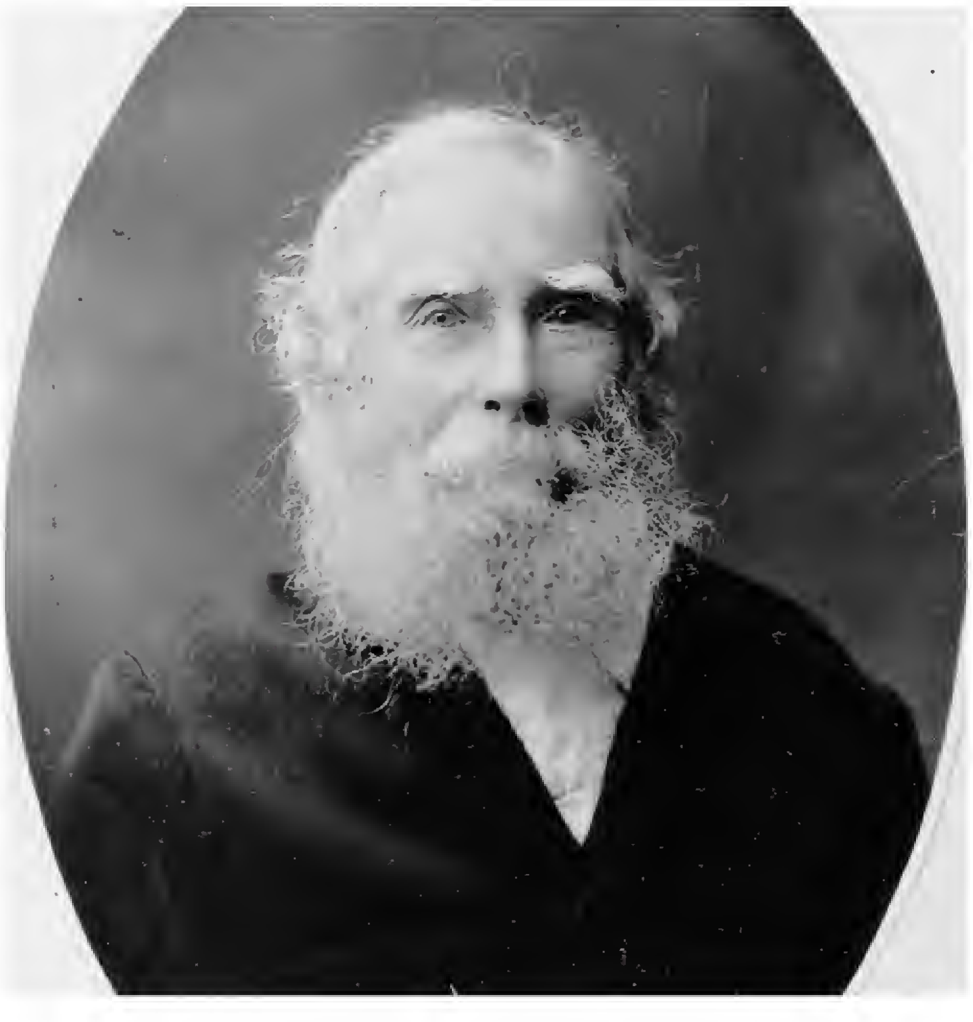


Fig. 1. Eugene (Fitzherbert Albini) Fitzalan, circa 1909. Photographer unknown. Reproduced with permission of the State Library of Queensland.

Fitzalan remains a somewhat enigmatic individual, with speculation about his childhood, ancestry and education in Ireland. Apart from a few details that Fitzalan himself provided during his lifetime, no documentation has been traced about his early life. It may be that some of the claims made by various authors about his ancestry and education were assumptions extrapolated from a few fragments of dubious information (Froggatt 1935; Turner 1943; Desmond 1994; Anon. [Friends of the Botanic Gardens, Cairns] 2001; Holmes 2002; Rutherford 2002; Grimwade *et al.* 2005;

Table 1. Taxa named for Eugene Fitzalan. The original epithet is listed first and the currently used name follows in parentheses, if different. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Adiantum hispidulum var. *fitzalani* F.M.Bailey (= *Adiantum diaphanum* Blume) (Pterid.). Type: Qld. Daintree River, 1875, *E.Fitzalan s.n.*; holo: MEL0692085.

'*Dendrobium fitzalanii F.M., Epi. Queensland*' (Orchid.) . Hill, W. (1875) *Catalogue of the plants in the Queensland Botanic Garden* [p. 35]. James. C. Beal: Brisbane. Type: not designated. *Nomen dubium.*

Eria fitzalani F.Muell. (= *Hymeneria fitzalanii* (F.Muell.) M.A.Clem. & D.L.Jones). Type: Holotype not located. Neotype: Qld. Massey Creek, McIlwraith Range, 4 Sept. 1979, *J.R. Clarkson 2604*; BRIAQ0381865.

'*Erythrina fitzalanii* (W.H.)' (Fab.). Burdekin expedition: botanical research. *The Mercury* (Hobart), Monday 26 November 1860, p. 3. "*Amongst the ornamental plants the Erythrina fitzalanii (W.H.), a scarlet flowering coral tree, twelve feet in height, is the gem of those collected during the expedition. Trees of it in flower were seen by the party six miles distant*". Type: not designated. *Nomen dubium.*

Eulophia fitzalanii F.Muell. ex Benth. (= *Eulophia bicallosa* (D.Don) P.F.Hunt & Summerh.) (Orchid.). Type: Qld. Mt Dryander, *E.Fitzalan s.n.*: holo: MEL677527.

Ficus fitzalani Miq. (= *Ficus opposita* Miq.) (Mor.). Type: Qld. Cape Cleveland, *E.Fitzalan s.n.*; U0004664.

Fitzalania F.Muell. (= *Meiogyne* Miq. (Annon.). Type species: *Fitzalania heteropetala* (F.Muell.) F.Muell. (= *Meiogyne heteropetala* (F.Muell.) D.C.Thomas, Chaowasku & R.M.K.Saunders). Type citation: *In insulis Cumberland Islands et prope portum Denison. E. Fitzalan.* Type: Qld. Cumberland Islands & Port Denison, *E.Fitzalan s.n.*; syn: BRIAQ0332759, MEL2064812–16, NSW453651.

Gardenia fitzalanii F.Muell. (= *Atractocarpus fitzalanii* (F.Muell.) Puttock) (Rubi.). Type: Qld. Cape Upstart & Magnetic Island, *E.Fitzalan s.n.*; holo: MEL598569.

Lepistemon fitzalani F.Muell. (= *Lepistemon urceolatus* (R.Br.) F.Muell.) (Convolvul.). Type: Qld. Trinity Bay, *E.Fitzalan s.n.*: MEL0304420.

Macropteranthes fitzalanii F.Muell. (Combret.). Type: Qld. Port Denison, *E.Fitzalan s.n.*; lecto: MEL1005516.

Musa fitzalanii F.Muell. (Mus.). Type: Qld. Daintree River, 1875, *E.Fitzalan 3*; syn: MEL657778–657782. NB: Possibly extinct, not subsequently recollected.

Psychotria fitzalanii Benth. (Rubi.). Type: Qld. Burdekin Expedition, *E.Fitzalan s.n.*; K000777505.

DIA 2014; Nelson 2014). An assessment of those claims is presently being made (Dowe & Nelson *in prep.*), and will not be discussed here. Suffice to say, Fitzalan claimed to have had horticultural training in Ireland, prior to his emigration to Australia (Maiden 1922; Kelly 1973; Hall 1978; Sundowner 1986; George 2009; Nelson 2014).

In addition to the lack of evidence about Fitzalan's early life, there is also mystery about his move to Australia. There are no known records of a Eugene Fitzalan [or spelling variants] arriving in Australia during the period 1848–1850. However, there were migrants, whose names were never officially recorded, arriving as crew or steerage passengers. The steerage section of a ship provided the cheapest rate of passage, and the names of many steerage passengers were not documented. This contrasts with those migrants who arrived on organised plans where details of name, occupation and origin were recorded on arrival in Australia.

Table 2. Geographic features and place names commemorating Eugene Fitzalan. Nomenclature is that presented in DRNM (2014).

Fitzalan Island [S20° 19' 50.4", E148° 57' 37.6"], Whitsunday Group, Queensland: Formally named in 1933 by Lieut. Commander C.G. Little, RAN of HMAS *Moresby*.

Fitzalan Point [S20° 19' 42.2", E148° 57' 46.3"], (no longer used) the most southern point of Whitsunday Island, immediately adjacent to Fitzalan Island.

Fitzalan Passage [S20° 18' 37.7", E148° 55' 52.1"], between Henning Island and Whitsunday Island, Queensland.

Fitzalan Creek [S16° 54' 02.4", E145° 44' 58.3"], Cairns, passes through Edge Hill and the Cairns Botanical Gardens, Queensland.

Fitzalan Garden [S16° 54' 00.8", E145° 44' 57.8"], a section in the Cairns Botanical Gardens.

Fitzallan Close [S16° 54' 54.4", E145° 43' 13.0"], Kanimbla, Cairns, Queensland.

Fitzalan Street [S19° 59' 48.1", E148° 13' 40.8"], Bowen, Queensland.

Table 3. Time-line of Eugene Fitzalan's primary plant collecting activities.

?1854:	Tasmania, dates not recorded
?1858–60:	Moreton Bay area, dates not recorded
1860:	The Burdekin Expedition, 22 August – 18 October
1861–1886:	Port Denison (Bowen)
1863:	Mount Elliot, Townsville area, August [collected with John Dallachy]
1869:	Mount Dryander, 5–8 November [collected with Frederick Kilner]
1870–74:	Whitsunday Islands
1872:	Mount Dryander, June (collected with Frederick Kilner) and July (collected with John Rainbird); Townsville area, September
1875–77:	Trinity Bay [Cairns], Cooktown and Daintree River
1880:	Daintree River
1881:	Mount Elliot (collected with John Rainbird) and Townsville area, November
1882:	Townsville area, February
1882:	Cairns area
1883:	Whitsunday area
1886–1896:	Cairns area
1887:	Atherton Tablelands

In contrast, Fitzalan's activities, movements and enterprises in Australia after 1852 are well documented (Dowe & Nelson *in prep.*). Through his nursery and seed collection and distribution activities, Fitzalan also made a significant contribution to horticulture in Queensland (Table 4).

This work aims to provide an assessment of Fitzalan's botanical collections within an historical context. Nine expeditions and excursions are examined in detail, and summaries of the itineraries and botanical activities are provided. For each, the specimens used in typification and in taxonomic citations are identified. As well as examining the way his collections were used in taxonomic research, the species lists provide an indication of floristic composition at the time at the locations where he collected.

The Burdekin Expedition, 1860

The Burdekin Expedition was among the first coastal surveys that the newly established Queensland Colonial Government arranged and funded. Queensland separated from New South Wales on 6 June 1859 (State of Queensland 1998), and the Colonial Declaration took place on 10 December of the same year (Queensland Government Gazette 1859). By August 1860, the Queensland Government (1860) had authorised the expedition, and the necessary personnel, equipment and vessels were organised (Smith 1860). Broadly, the expedition was seen as a way to foster settlement in north Queensland, and to ascertain agricultural and pastoral potential. In particular, it was to locate the mouth of the Burdekin River, and to determine if the river was navigable and suitable as a port.

The circumstances which led to Eugene Fitzalan being engaged as the botanical collector on the expedition are not documented. Prior to this, he had been collecting for

Table 4. The main horticultural activities in which Eugene Fitzalan was involved.

1855:	Proprietor of *Elvaston Gardens*, Barwon River, Geelong
1860:	Proprietor of a plant and seed shop, Brisbane [Edward Street]
1860–1897:	Donations to, and exchanges with, the Melbourne Botanic Gardens, Geelong Horticultural Improvement Association, Brisbane Botanic Gardens, Calcutta Botanic Gardens and Bogor Botanic Gardens
1861–1870	Established gardens in Bowen
1872–1886:	Proprietor of *Willow Vale Gardens*, Bowen
1873–1897:	Donations to, and exchange with, the Queensland Acclimatisation Society
1879–1886:	Curator of Bowen Botanical Reserve
1887–1897:	Caretaker/Curator of Cairns Botanical Reserve
1887–1897:	Proprietor of *Rosebank*, Cairns
1897–1911:	Florist, West End, Brisbane

Ferdinand Mueller in Tasmania and near Brisbane (MELISR 2014). Fitzalan's Tasmanian collections are scant and poorly documented (Mueller 1869) but his Brisbane collections show a significant increase in numbers and improvement in quality, which suggests that upon moving to Brisbane he had become more involved with botanical activities. The terms of his contract are not known. For the Burdekin Expedition, he was on secondment to the Queensland Government but with his salary provided by the Victorian Government. In correspondence from Fitzalan to the Premier's Department in 1868, he wrote that "*I accompanied this expedition as a botanical collector in the pay of the Melbourne Government*" [2]. His plant collections were first examined by the Queensland Government Botanist Walter Hill in Brisbane, and then subsequently sent to Mueller in Melbourne.

There are a number of reports that have relevance to the itinerary, botanical activities and collections of the Burdekin Expedition (see Dalrymple 1860; Fitzalan 1860; Hill 1860a, 1860b; Mueller 1860b; Smith 1860). As the focus here is botanical, much of the incidental and exploration consequences are not dealt with. There were minor discrepancies between dates of events between the reports, so a consensus approach has been taken. All quotes are verbatim with the original spelling retained. Locations are kept as the original followed by the current name in square brackets. Similarly for distances, originally given in imperial measurements, but converted to metric and included in square brackets. Species identifications are largely tentative, but based on analysis of the available descriptions and known herbarium specimens collected by Fitzalan during the

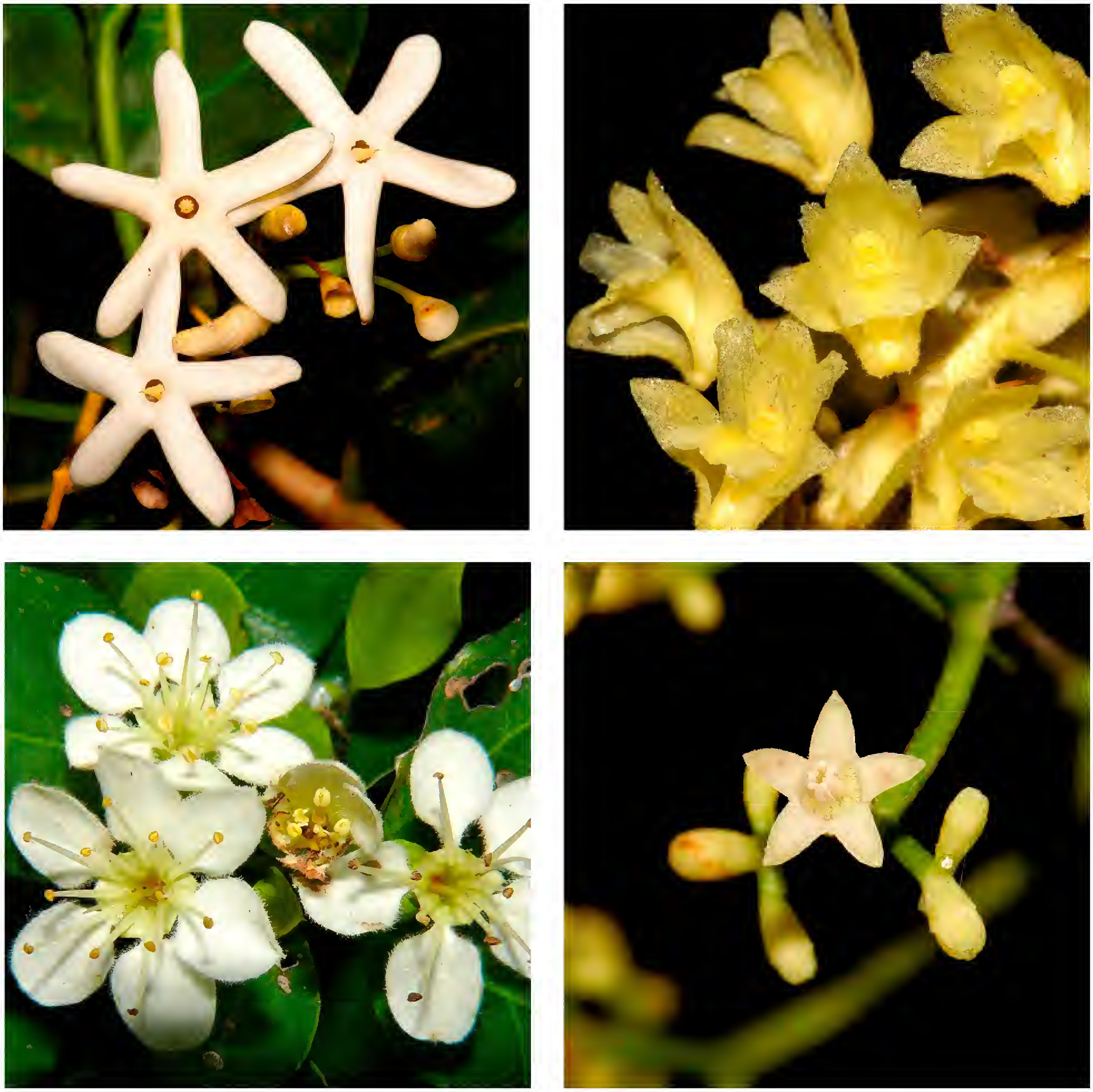


Fig. 2. Plant species named for Eugene Fitzalan. Top left: *Atractocarpus fitzalanii (*F.Muell.) Puttock) (Photo: J.L.Dowe). Top right: *Hymeneria fitzalanii* (F.Muell.) M.A.Clem. & D.L.Jones) (Photo: J.L. Dowe). Bottom left: *Macropteranthes fitzalanii* F.Muell. (Photo: Steve Pearson). Bottom right: *Psychotria fitzalanii* Benth. (Photo: J.L.Dowe).

expedition. Where there is a probable connection between the species and an herbarium specimen, the relevant herbarium specimen record is given after the species in square brackets. The majority of Fitzalan's herbarium specimens are conserved in MEL [National Herbarium of Victoria]. There has been no attempt to provide typification or corrected identifications for the specimens as these aspects are beyond the scope of this present work.

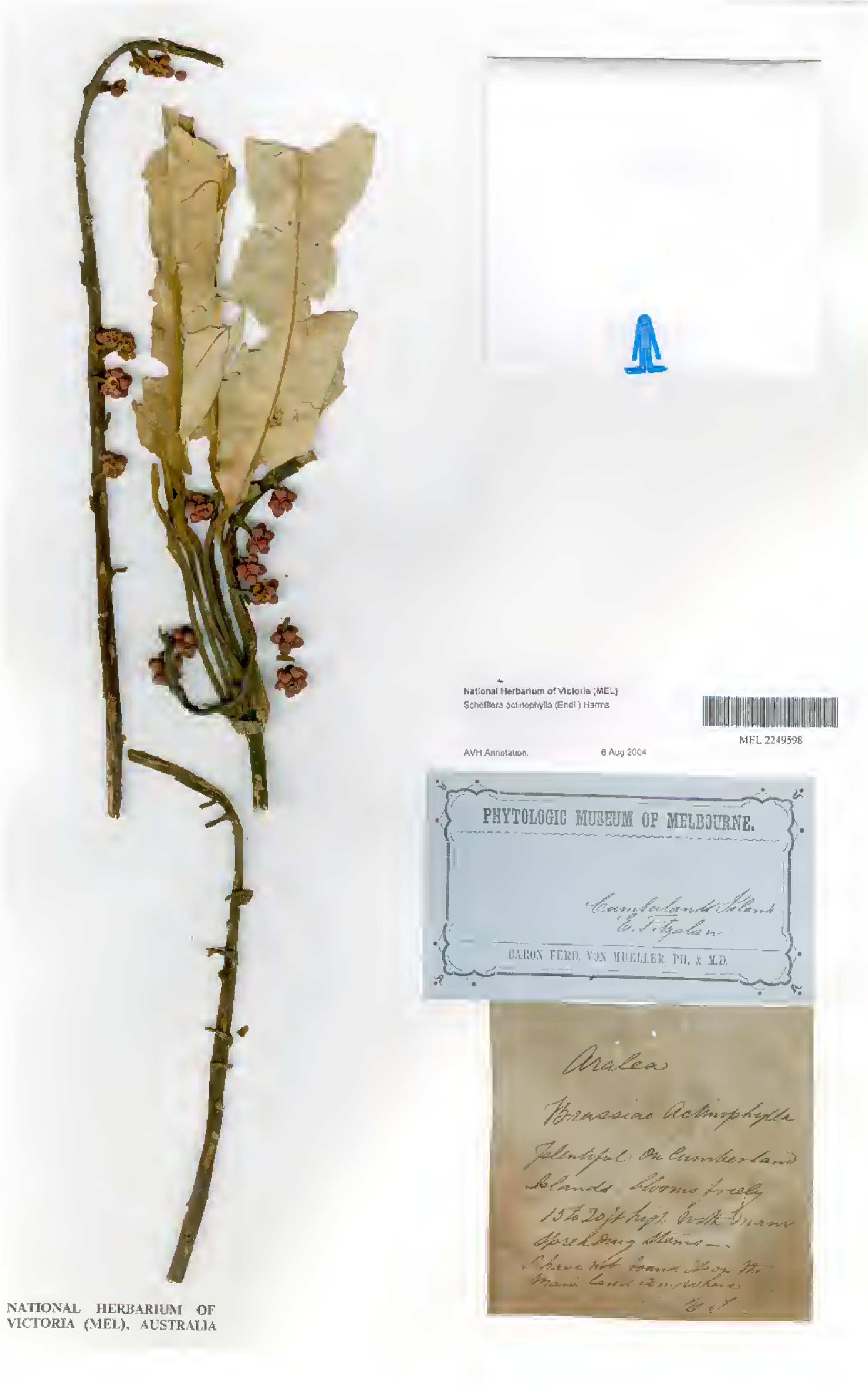
The collection labels originally provided by Fitzalan in many cases have not survived, and those which have survived provide limited information. Very few are dated, and locality descriptors are very broad: for example Burdekin Expedition, Burdekin River Estuary, Cumberland Islands or Port Denison, etc. (Figure 3). Taxonomy is that presented in the Australian Plant Census (2014) and Australian Plant Name Index (2014), and place names follow those provided by DNRM (2014).

The Burdekin Expedition itinerary

On the evening of **Wednesday 22 August 1860**, the crew boarded H.M. Colonial Schooner *Spitfire* which was anchored at Customs House, Brisbane. The *Spitfire* (Figure 4) was a rigged ketch of 60 tons [54.4 MT], length of 62 feet [18.9 m], beam of 16 feet [4.8 m] and draught of 5 feet 6 inches [1.7 m] (Jones 1998). The ship's company included:

- Commander Joseph W. Smith RN (b. ?; d. ?), a Royal Navy Officer who was employed by the Queensland Government to command the Burdekin Expedition and was formerly Master of H.M.S. *Herald* (Jones 1998).
- George Elphinstone Dalrymple (b. 6 May 1826, Aberdeenshire, Scotland; d. 22 Jan. 1876, England), explorer, public servant, politician and Commissioner of Crown Lands for Queensland [1860-1863] (Farnfield 1968; Austin & Lack 1972).
- Robert Phippen Stone (b. 1837; d. 11 May 1885), surveyor and cartographer and assistant to Joseph W. Smith and 3rd Master of the *Spitfire*.
- Mr Bousfield (also Bausfield), Master of the *Spitfire*.
- Eugene Fitzalan, botanical collector.
- seven seamen.
- two Aborigines, James Alexander and the other name not recorded.

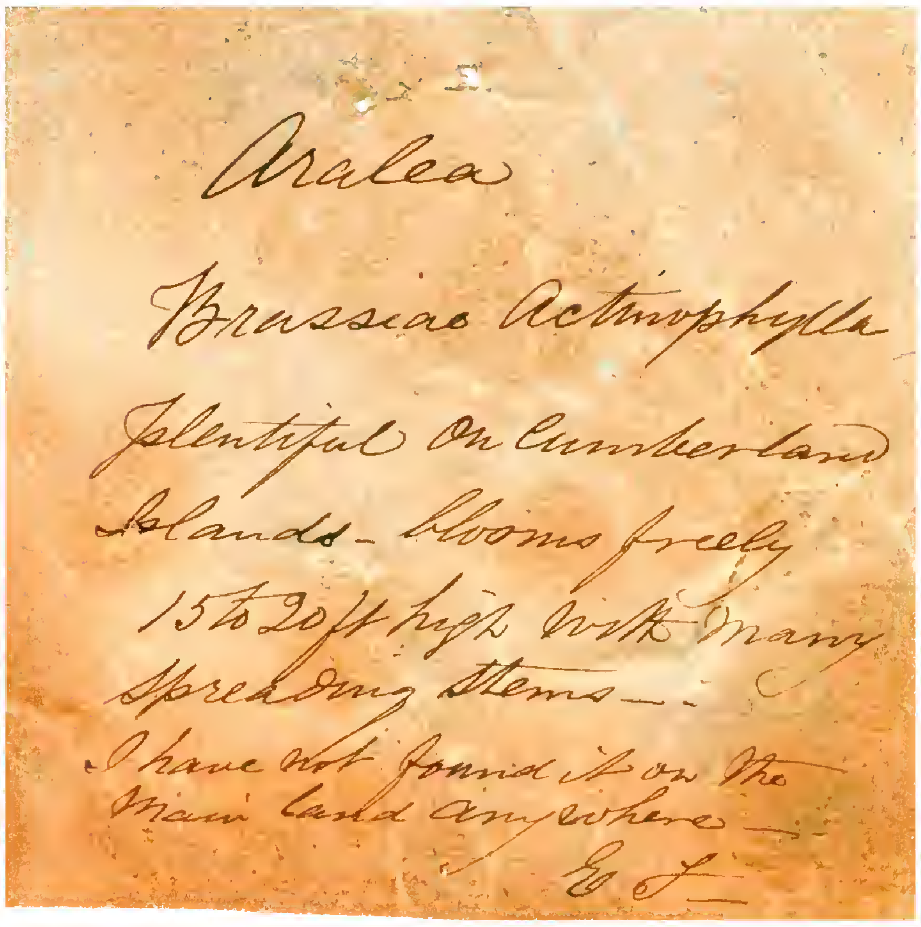
The following day, **Thursday 23 August**, the *Spitfire* departed Brisbane and spent the next few days anchored off Moreton Island, allowing the ship's chronometers and other equipment to be calibrated, and for water to be taken on board. On the morning of **Sunday 26 August,** the ship sailed from Cape Moreton, and headed north.



National Herbarium of Victoria (MEL)
Schefflera actinophylla (Endl.) Harms
AVH Annotation. 6 Aug 2004
MEL 2249598

PHYTOLOGIC MUSEUM OF MELBOURNE.
Cumberland Island
E. Fitzalan
BARON FERD. VON MUELLER, PH. & M.D.

NATIONAL HERBARIUM OF VICTORIA (MEL), AUSTRALIA



Aralea
Brassiae Actinophylla
plentiful on Cumberland
Islands - blooms freely
15 to 20 ft high with many
spreading stems -
I have not found it on the
main land anywhere -
E. F.

Fig. 3. Example of a specimen collected by Eugene Fitzalan. **Left:** *Schefflera actinophylla* [as *Brassiaea actinophylla*] [MEL2249598] collected from the Cumberland Islands during the Burdekin Expedition. Reproduced with permission from the National Herbarium of Victoria (MEL), Royal Botanic Gardens Melbourne. **Right:** Detail of label of *Schefflera actinophylla*.

It appears that one of the first land-falls was Lady Elliot Island, as Mueller (1860b) reported that the orchid '*Phajus australis* F.M.' [3] was collected from *"Lady Elliot's Island, off Wide Bay"* during the expedition. It is suspected that this is possibly a labelling error, as habitats suitable for swamp orchids do not occur on the island. However, specimens of *Phaius australis* are extant in MEL, and correctly identified. There was no date recorded for this event, but the most likely date that they would have been in the vicinity of Lady Elliot Island was around **Tuesday 28 August**. None of the other reports mentioned making land-fall at Lady Elliot Island [or indeed any land-fall in the first three days of the Expedition].

On the morning of **Thursday 30 August,** they entered the Fitzroy River mouth, and were at anchor at Rockhampton by the evening. A few days were spent at Rockhampton, and Fitzalan "*saw here for the first time a splendid deciduous tree, known as the Leichhardt tree* [4]*… I brought samples of it sawn into boards with me to Brisbane, and feel convinced that when polished it will be an ornamental satin wood*" (Fitzalan 1860). On **Saturday 1 September,** they departed Rockhampton in the afternoon and anchored about 10 miles [16 km] downstream in the Fitzroy River for the night. The following day, **Sunday 2 September**, the *Spitfire* became grounded in the lower reaches of the Fitzroy River, and Fitzalan (1860) noted that it "*gave some of us the chance of going ashore for a couple of hours*".

At high tide on **Monday 3 Sept**, the *Spitfire* was able to depart the Fitzroy River, and traversed Keppel Bay before anchoring off Curtis Island, near Sea View Hill [Sea Hill] for the night. At daylight on **Tuesday 4 September,** they departed Curtis Island, and sailed through the day and the night. High Peak Island was passed at about 8.30 am on **Wednesday 5 September** and by noon Percy Island No. 1 [South Island] was being approached. Some observations on the vegetation were provided by Fitzalan (1860) that "*there is an abundance of pine here, of a better quality than that of Moreton Bay* [5]". By mid-afternoon, the ship was anchored in a harbour formed by Percy Island No. 1 [South Island], Percy Island No. 2 [Middle Island] and Percy Island No. 6 [North East Island]. In the late afternoon, a party, including Fitzalan, went ashore at Percy Island No. 1 [South Island] near the Beale's Creek watering place [exact location not known], but returned to the ship for the night.

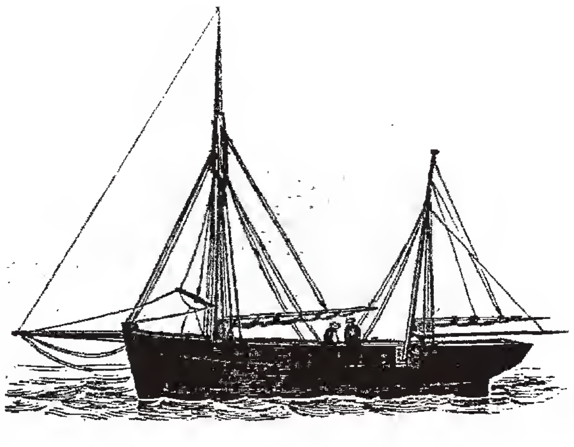


Fig. 4. H.M. Colonial Schooner *Spitfire*. Illustrated Sydney News 1855, 14 April.

On the morning of **Thursday 6 September**, a party, including Fitzalan, went ashore to collect additional water and Fitzalan (1860) "*found some interesting plants here, one of which may probably be used as an ornamental timber – the Calophyllum* [6]*. The trunk of the tree I saw was about two feet in diameter, very hard and close-grained, and prettily veined; it would be good for turning purposes, and I believe would answer the purpose of the wood engraver. I got specimens of several ornamental shrubs* [7] *here"*. Hill (1860a) elaborated on Fitzalan's collections: "*On Percy Island was found growing in the sandy soil a calophyllum* [8]*, a beautiful spreading tree, about fifty feet in height and twenty-four inches in thickness. The tree, when wounded, exudes a yellowish, bitter juice, frequently hardened to a gum… On this island was also seen a yam* [9]*, which is greatly sought after by the natives"*. Dalrymple (1860) reported on some of Fitzalan's activities and also an event involving other voyagers who had previously visited the island: "*the botanical collector attached to the expedition, here obtained specimens of a new and very beautiful terrestrial orchid, Vanda Ceruliensis* [10]*. Mr. Hill, Director of the Botanical Gardens at Brisbane, first discovered this beautiful plant on No. 2 Percy in 1854; but the attack of the aborigines, which resulted in the murder of his* [Walter Hill's] *companion, Mr. Strange, obliged him to abandon his specimens*". Some clarification of the identity of Dalrymple's '*Vanda Ceruliensis*' was provided by Hill (1860b): "*Two beautiful plants of the Dendrobium luridum* [11]*, and its variety, with yellow flowers, were also collected on the island*".

At about 2.30 pm in the afternoon of **Thursday 6 September**, they departed Percy Island No. 1 [South Island], then sailed between Percy Island No 2 [Middle Island], Sphinx Island and Pine Island. Prudhoe Island was passed at about at 9.00 pm, and they continued to sail during the night (Figure 5). At 10.00 am on **Friday 7 September** they passed Flinders' 'L' Island [Scawfell Island], and at noon passed Flinders' 'M' Island [Brampton Island]. Observations of the abundance of pines were made here by Mueller (1860b) based on Fitzalan's notes: "*Araucaria cunninghami Aiton.* [12]*…Cumberland Islands…Mr. Fitzalan offers on this pine the following notes:- "Very abundant from Percy's Islands upwards. On Percy Islands it differs but little from the Moreton Bay pines, except in the invariable regularity of its branches, these being in regular tiers opposite"*. In response to what may have been the sound of a gunshot, they anchored off the northern shore of 'M' Island [Brampton Island] and went ashore in the afternoon at about 2.00 pm for about one hour to investigate. On approaching an Aboriginal campfire, they determined that the noise possibly came from an exploding rock that had been placed in the fire. The camp and canoes had been recently abandoned in fright by the Aboriginal inhabitants, and Fitzalan (1860) related that "*we found in every one of the canoes a piece of the stem of an orchid* [13]*, which is plentiful on the islands, about six inches long, for which we could not conjecture the use*". Anchoring off 'H' Island [Carlisle Island], they spent the night there (Figure 5).

Hill (1860b) listed these species for the Percy and Cumberland islands:

7. Sapotaceae, a handsome tree [14]*, wood solid, heavy, close grained, fruit not eatable. Percy Island.*

40. Fabaceae, a small shrub [15]*. Percy Islands.*

72. Orchidaceae, an epiphytic plant [16]*, one of the most beautiful of the Australian orchids, with spikes of olive-coloured flowers, and 2 feet long. Percy Island.*

90. Clusiaceae, a beautiful tree [17]*, with thick milky sap. Percy Island.*

120. Convolvulaceae, seeds [18]*. Percy Island.*

65. Pinaceae, a magnificent tree [19]*, timber white, close grained, can be procured in great quantities on Cumberland and other islands.*

88. Fabaceae, a small shrub [20]*. Cumberland Island.*

89. Proteaceae, a pretty shrub [21]*. Cumberland Island.*

On the morning of **Saturday 8 September** they departed ‘H’ Island (Carlisle Island], to sail past Linhe Peak [Linne Island] and other islands of the Sir James Smith’s Group. Further observations were made by Dalrymple (1860) on the abundance of pines and that they have “*many characteristics of the Pinus Cunninghamei* [22]*, approach more to the Pinus Cookei* [23] *of the New Caledonian variety*”. At nightfall they sailed past Shaw’s Peak [Shaw Island], and anchored off the western point (Figure 6). On the morning of **Sunday 9 September** they departed Shaw Island, and by 8.00 am had entered the Whitsunday Channel, narrowly missing a small underwater pinnacle peak which they named Spitfire Rock.

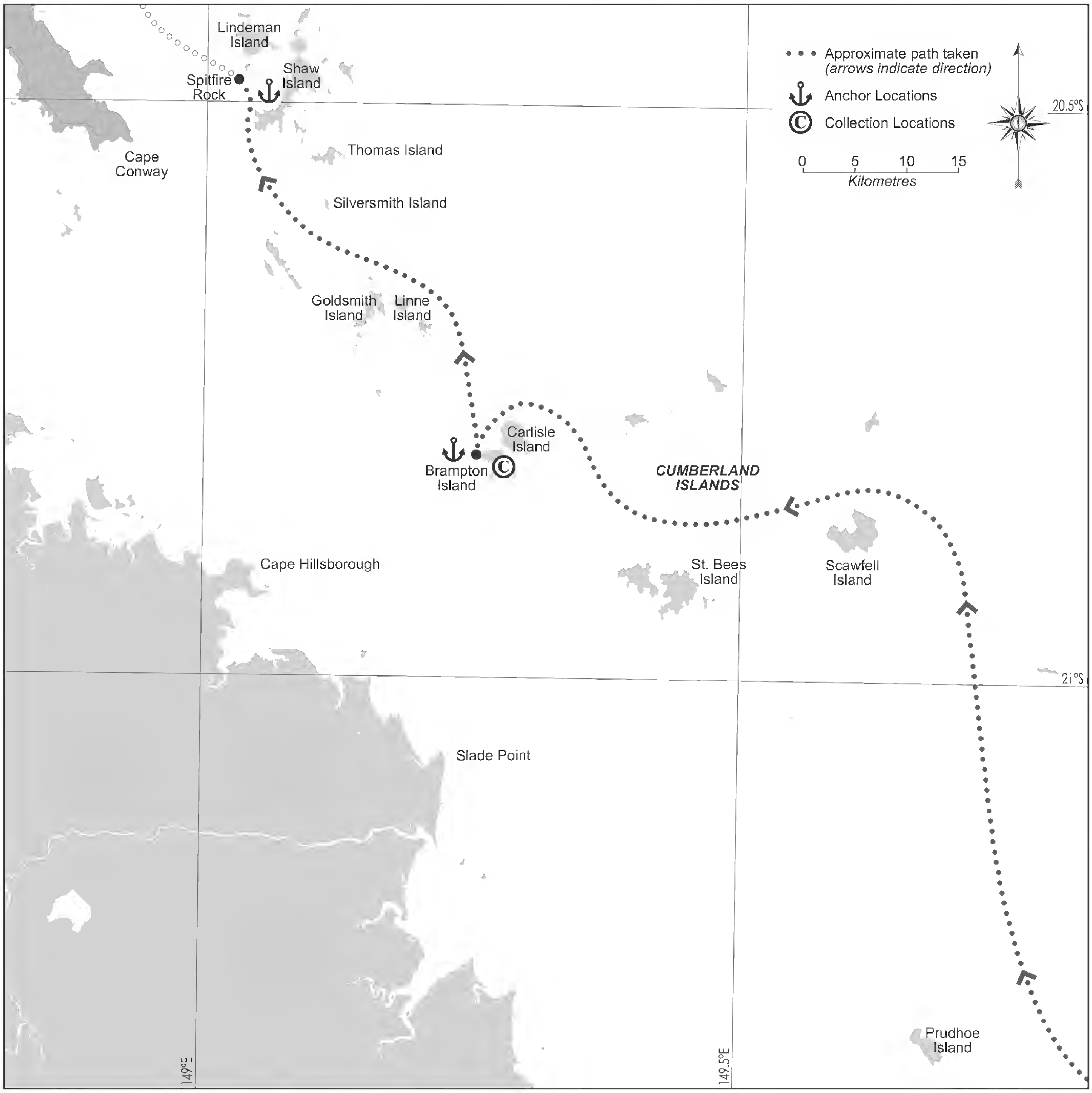


Fig. 5. Map of the approximate path taken during the Burdekin Expedition, Prudhoe Island to Shaw Island, 7–8 September 1860. Prepared by Claire Burton, Cairns Regional Council.

They passed through the straits between Cape Conway, Pine Head [Pine Island] on one side and Pentecost Island, Whitsunday Island, and Passage Islands [Hamilton Island and Dent Island] on the other, and at about 2.00 pm rounded Molle Head and entered Port Molle to anchor in the south of the harbour opposite a beach on the northern face of Smith's Boomerang Island or Fitzalan's Molle Island [Long Island]. Here they went ashore for about four hours. On Long Island Fitzalan (1860) observed an *Erythrina* in flower: "*we saw in the centre of one of the patches of scrub…a tree of such an intense scarlet that it was visible at a distance of several miles. I made my way to this spot, and found it to be a new Erythrina* [24]*, completely covered with large scarlet blossoms, but without a single leaf on it. This is the most beautiful tree I have ever seen*". Smith (1860) was similarly impressed with the *Erythrina*: "*Here* [Long Island]*, and at every place we visited, geological and botanical specimens were obtained; among the latter, a most beautiful flower of a scarlet color, completely covering the few trees which we saw. Upon close examination it was observed that, at this season, there were no leaves on the tree, which has a whitish bark, and is about 20 ft in height. I regret to find that unfortunately we failed in preserving our specimens of this magnificent flower*". Hill (1860b) provided a provisional name for the *Erythrina*: "*Amongst the ornamental plants the Erythrina fitzalanii (W.H.)* [25]*, a scarlet flowering coral tree, twelve feet in height, is the gem of those collected during the expedition. Trees of it in flower were seen by the party six miles distant*". Fitzalan (1860) summarised the vegetation on Long Island: "*Molle Island* [Long Island] *has a greater variety of trees and shrubs than any place of its size I have ever been on, many of them new and interesting species. There was a palm* [26] *on this island which we saw while coasting along that was new to me, but we could not get to it, as we had but four hours on the island*". Similarly, Dalrymple (1860) provided a synopsis on the vegetation: "*The Seaforthia* [27] *and Pandanus palms* [28]*, the Araucaria cookie* [29] *, bottle trees* [30]*, acacias* [31]*, a splendid scarlet flowering Erythrina* [32]*, and Hybiscus* [33]*, were observed in the thickets of Molle Head. Eucalypti* [34]*, Ash* [35]*, Tea-trees* [36]*, Figs (Ficus elastica* [37]*) formed the forest of the lower hills and flats*". Hill (1860b) provided additional remarks on the plants that were collected: "*At Port Molle, a beautiful Apocynaceae* [38] *was discovered, loaded with scarlet fruit, which is not eatable. The tree when wounded exudes a milky juice, and is very adnate, approximating to gutta percha* [39]".

Hill (1860a) listed these species for Port Molle:

2. Araliaceae, a small growing tree [40]*. Port Molle.*

51. Euphorbiaceae, a shrub, with bright green foliage [41]*. Port Molle.*

91. Fabaceae, a small tree [42]*. Port Molle.*

92. Asteraceae, an herbaceous plant [43]*. Port Molle.*

96. Graminaceae, a small growing grass [44]*. Port Molle.*

105. Compositae, a very showy herbaceous plant [45]*. Port Molle.*

114. Euphorbiaceae, herbaceous plant [46]*. Port Molle.*

They departed Port Molle at daylight on **Monday 10 September**, moving to about 5 miles (8 km) off-shore. By about 6.00 pm, they passed within about 1 mile [1.6 km] of Cape Gloucester, and by about 8.00 pm rounded the northern tip [Gloucester Head] of Gloucester Island, where they anchored for the night (Figure 6). On the morning of **Tuesday 11 September**, anchor was weighed and they entered Edgecumbe Bay, passing within about 1 mile [1.6 km] to the south of Middle Island and entered Port Sinclair [Port Denison]. By 10.00 am they were anchored off Stone Island, facing the centre of the port. Soon after, Smith (1860) reported that "*Messrs. Dalrymple and Stone, with a small party, ascended the western heights of Mount Gordon*". Dalrymple (1860) provided some notes on the vegetation observed and collected on Mount Gordon: "*A new Hybiscus* [47] *was found in the scrub of the hill top: also a bush with hook-shaped thorns, like the 'Wait-a-bit thorn" of the Cape of Good Hope* [48]*. Quantities of the small fig* [49] *were also found on the summit of Mount Gordon*". They returned to the ship and remained anchored off Stone Island for the night.

Hill (1860a) listed this species for Mount Gordon:

42. Sapotaceae, a small tree [50]*. Mount Gordon.*

At daylight on **Wednesday 12 September**, they departed Port Sinclair [Port Denison]. They moved to within about 1½ miles [2.4 km] off Cape Edgecumbe, and by 3.00 pm were sailing close to the coast near Cape Upstart (Figure 7). In late afternoon they anchored off the western side of Cape Upstart and went ashore for a couple of hours. They proceeded inland and Dalrymple (1860) "*named the hill I ascended Mount Myrtacea, from a very fragrant and pretty species of the myrtle* [51] *with small white blossoms scented like hawthorn, found among the rocks of its summit by Mr. Fitzallan*". A number of new species were observed by Fitzalan (1860) in this area: "*It was here I first met with the native cotton tree* [52]*, but it was only in blossom. There is a palm very plentiful here which the natives gather the fruit of, and in great quantities of it; it is a cycas* [53]". Hill (1860b) attempted an identification based on Fitzalan's collection: "*At Cape Upstart, the arborescent Gomphocarpus* [54] *(or native cotton) was seen partly covered with its beautiful yellow flowers, while other parts of the tree were laden with pods containing the fibrous substances*". The cycas was annotated by Mueller (1860b) based on Fitzalan's notes: "*Cycas media R.Br.* [55] *…Cape Upstart. This plant attains, according to Mr. Fitzalan's notes, a height of 70 feet*". Mueller (1860b) further accounted for "*Gardenia ochreata F.M.* [56]*…Abundant on the granite hills of Cape Upstart. Mr. Fitzalan observes that the fruit is eaten by the natives*". They remained at anchor here for the night.

Hill (1860a) listed these species for Cape Upstart:

5. Rubiaceae, an ornamental tree [57]*. Cape Upstart.*

21. Malvaceae, a small tree [58]*. Cape Upstart.*

27. Myrtaceae, a small tree [59]*. Cape Upstart.*

29. Fabaceae, a small tree with graceful pendant foliage [60]*. Cape Upstart.*

> *36. Myrtaceae, a small tree* [61]*, of little value. Cape Upstart.*
>
> *57. Cedrelaceae, a lofty tree* [62] *with cylindrical stem and ample head, well clothed with pinnate foliage. Cape Upstart.*
>
> *58. Pittosporaceae, a shrub* [63]*, with spikes of white blossoms. Cape Upstart.*
>
> *102. Moraceae, a tree* [64] *about 30 feet high, with soft wood. Cape Upstart.*

During **Thursday 13 September**, Dalrymple and Fitzalan rowed across Upstart Bay and went ashore to climb to the top of a hill [Big Hill near Wunjunga] to make observations (Figure 7). They returned to the *Spitfire* and remained at anchor off the western side of Cape Upstart for that night. During the morning of **Friday 14 September**, they went ashore at Cape Upstart and ascended Station Hill [Signal Hill] where Fitzalan (1860) "*sowed some pumpkin seed on the top of the Cape, and everywhere we went ashore*". They returned to the boat and weighed anchor and sailed past Cape Bowling Green at about 9.00 am. Travelling close to the coast during the rest of the day, they sailed into the night, before reaching Cape Cleveland at about 8.00 am on **Saturday 15 September**, and anchoring off the west coast in the vicinity of White Rock (Figure 8). At about 9.00 am, Fitzalan, Dalrymple and James Alexander went ashore, as noted by Fitzalan (1860) "*while Mr Smith and Mr. Stone were taking observations on a rock which stood some distance out from*

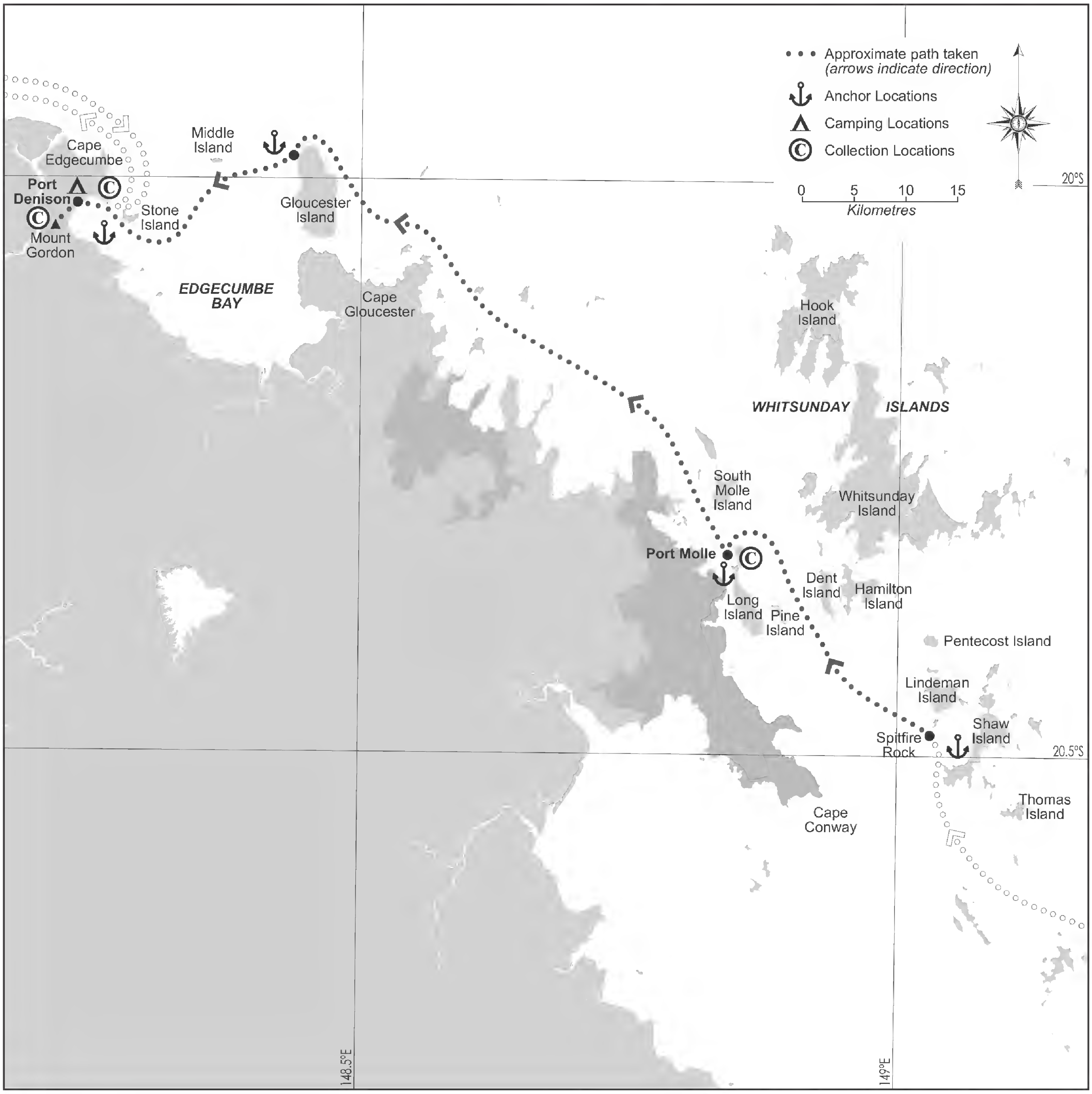


Fig. 6. Map of the approximate path taken during the Burdekin Expedition, Shaw Island to Port Denison, 9–11 September 1860. Prepared by Claire Burton, Cairns Regional Council.

the shore protected by the boat's crew, Mr. Dalrymple and myself went upon the beach". They remained at anchor here on **Sunday 16 September** until the morning of **Monday 17 September**, after which they sailed to the northern side of Magnetical Island [Magnetic Island] and into Halifax Bay. At about 5.00 pm, somewhere near the northern cape of Magnetic Island they went ashore and Fitzalan (1860) reported that "*having sprung our topmast we went ashore on this island to cut a pine spar to replace it in case it broke. There is plenty of pine* [65] *on this island. The wood is very hard and white, and would not swim*". At about 7.00 pm, they anchored for the night in Halifax Bay on the western side of Magnetic Island between it and the mainland, with Bay Rock to the W/N by 1½ miles [2.4 km].

Hill (1860a) listed these species for Upstart Bay and Magnetic Island.

53. Apocynaceae, a tall tree [66]*, with some beauty. Upstart Bay.*

84. Fabaceae, a climber [67]*. Signal Hill, Upstart Bay.*

25. Myrtaceae, one of the species known under the name of Blue Gum and Grey Gum [68]*. Plentiful on Magnetical Island.*

34. Myrtaceae, a small shrub [69]*. Magnetical Island.*

69. Fabaceae, a small shrub [70]*, growing on the granite hills. Magnetical Island.*

85. Fabaceae, a shrub [71]*, with silvery leaves. Magnetical Island.*

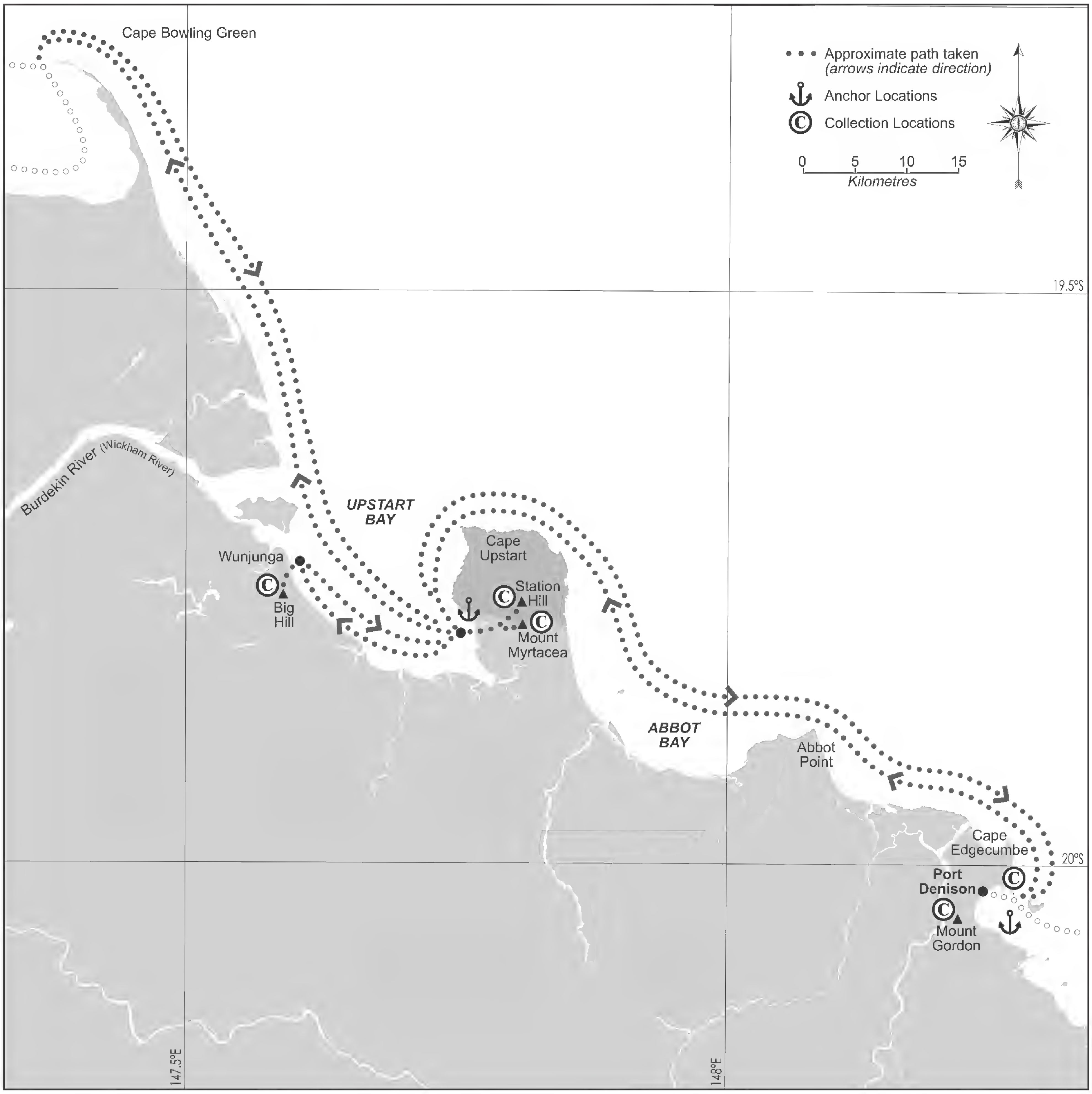


Fig. 7. Map of the approximate paths taken during the Burdekin Expedition, Port Denison to Cape Bowling Green, 12–14 September, 26 September–9 October 1860. Prepared by Claire Burton, Cairns Regional Council.

Hill (1860b) and Mueller (1860b) listed respectively these species for Magnetic Island: "*The Araucaria cunninghamii (var glauceae)* [72] *was also among the collection…a tree was cut on Magnetical Island. Its wood was remarkably white and close grained*", and "*Loranthus vitellinus* [73] *… On the branches of Eucalypti, Bursaria, Ficus, arborescent Grevilleae and other trees, Magnetical Island, Fitzalan*".

Tuesday 18 September was spent examining the coast of Halifax Bay, to as far north as "*latitude 19 deg. south*" [just south of the Palm Islands]. They returned to the same anchorage as the previous night near Magnetic Island. At daybreak on **Wednesday 19 September**, they went ashore on a southern headland of Halifax Bay [Cape Pallarenda], where they climbed a hill to get observations. From here they sailed into Cleveland Bay where they anchored for the night.

> Hill (1860a) listed these species for Halifax Bay:
>
> *86. Malvaceae, a small tree* [74]*, 20 to 30 feet high. Halifax Bay.*
>
> *104. Fabaceae, small shrub* [75]*. Halifax Bay.*
>
> *119. Fabaceae, seeds* [76]*. Halifax Bay.*

During **Thursday 20 September**, Fitzalan and Stone examined the coast of Cleveland Bay, and Dalrymple and Smith rowed up Crocodile Creek for about 8 miles [12.9 km], with Smith (1860) reporting that he "*despatch*[ed] *Mr. Stone with the botanical collector in one boat*". They remained at anchor here for the night. At daybreak on **Friday 21 September**, they went ashore and climbed the most western peak of Cape Cleveland. Returning to the boat, they moved slightly further north, where Fitzalan and a companion [Mr Stone?] were put ashore to walk across the northern part of Cape Cleveland, and to rendezvous with the boat on the eastern shore. Fitzalan (1860) noted that "*it was here* [eastern point of Cape Cleveland] *I found the pods of the native cotton* [77]*, but as the pods were not ripe the cotton cannot be considered a fair sample; I doubt if they had obtained their full size. This tree, if it does not become useful, will be at least highly ornamental*". It was also here that Fitzalan collected a species of *Hoya* as annotated by Mueller (1860b): "*Hoya dalrympliana* [78] *…On granite hills at Cape Cleveland…The interest evinced during the expedition by Mr. Dalrymple in the botanical investigations of Mr. Fitzalan has prompted me to name this new plant in honour of that gentleman*". A plant reputed to be toxic was noted by Hill (1860b): "*At Cape Cleveland fruits of the Cycas circinalis* [79] *were obtained and eaten by the party, and found to be very agreeable*". Upon meeting the boat after their traverse of Cape Cleveland, they sailed into the western part of Bowling Green Bay, and at sunset anchored about 9 miles (14 km) to the south-east of Cape Cleveland for the night.

> Hill (1860a) listed these species for Cleveland Bay and Cape Cleveland:
>
> *121. Malvaceae, seeds* [80]*. Cleveland Bay.*
>
> *122. Celastraceae, a small tree* [81]*. Cleveland Bay.*
>
> *9. Rubiaceae, an ornamental tree* [82]*, same as No. 5* [Cape Upstart]*. Cape Cleveland.*
>
> *10. Anacardiaceae, a robust growing tree* [83] *with large primate* [pinnate] *leaves, and producing large racemes of purple fruit. Cape Cleveland.*
>
> *1. Rubiaceae, a small shrub* [84]*. Cape Cleveland.*
>
> *12. Meliaceae, a large growing tree with primate* [pinnate] *leaves* [85]*. Cape Cleveland.*
>
> *23. Fabaceae, a shrub of little value* [86]*. Top of Cape Cleveland.*
>
> *28. Myrtaceae, a large tree* [87] *with stout trunk and spreading branches, full of foliage; wood close grained and hard. Common at Cape Cleveland.*
>
> *41. Thymelaceae, a shrub* [88]*, 6 to 8 feet high. Cape Cleveland.*
>
> *66. Fabaceae, a handsome spreading shrub* [89]*. Cape Cleveland.*
>
> *71. Verbenaceae, a nice flowering shrub* [90]*. Cape Cleveland.*
>
> *77. Fabaceae, a beautiful shrub* [91] *with yellow flowers. Cape Cleveland.*
>
> *82. Malvaceae, a shrub* [92]*. Cape Cleveland.*
>
> *93. Fabaceae, a small shrub* [93]*. Cape Cleveland.*"
>
> *110. Malvaceae, a large shrub* [94]*. Cape Cleveland.*"
>
> *125. Sterculiaceae, seeds* [95]*. Cape Cleveland.*"

Mueller (1860b) listed this species for Cape Cleveland: "*Pseudanthus pimeloides Sieber* [96]*…Flowers, according to Mr. Fitzalan, white in a recent state*".

On the morning of **Saturday 22 September**, they moved closer to the coast and anchored off Mount Elliot. Fitzalan and a 'companion' rowed up a narrow mangrove-lined stream [Haughton River] for about 12 miles [19.3 km]. At about 1.00 pm they went ashore for 'dinner', after which they returned downstream and re-joined the boat which remained at anchor for the night. On **Sunday 23 September**, they examined the coast of Bowling Green Bay, and anchored near the mouth of a small creek [Barratta Creek], where they spent the night. The following day, **Monday 24 September**, Fitzalan, Dalrymple and Smith rowed along the coast of Bowling Green Bay, and then up the small creek [Barratta Creek] for about 18 km, where they camped overnight on an open flat. The following morning, **Tuesday 25 September**, they rowed down the small creek [Barratta Creek], and joined the boat at about 1.00 pm. They weighed anchor and sailed out of Bowling Green Bay and through the night into Upstart Bay, anchoring in the afternoon of **Wednesday 26 September** on the northern side of Cape Upstart, near the anchorage place of the previous week for the night.

> Hill (1860a) listed these species for Bowling Green Bay:
>
> *65. Staticeae, a very showy herbaceous plant* [97]*. Bowling-green Bay.*
>
> *95. Fabaceae, a small plant* [98]*, resembling the sensitive plant. Bowling-green Bay.*

A party, including Fitzalan, went ashore at Cape Upstart on **Thursday 27 September**, spending all day there. On

Friday 28 September, they anchored off the western coast of Upstart Bay [near Wunjunga], where they went ashore to climb a hill, Beach Mount [Big Hill], to gain a view of the Wickham River [Burdekin River] mouth. They had climbed this hill on a previous visit, but undertook this second climb with the new knowledge that the Wickham River was most likely the Burdekin River. They departed about midday, setting a direct course for Port Sinclair [Port Denison] and sailed through the night.

They entered Port Sinclair [Port Denison] at about 4.00 pm on **Saturday 29 September**, and anchored off Stone Island. They remained at anchor here until Tuesday 9 October. Meanwhile, Fitzalan spent all of **Sunday 30 September** on Stone Island: "*This is the Garden Island of Sinclair and Gordon – the garden being a patch of swampy ground in which a yam* [99]*, of which the natives are very fond, is plentiful…I brought away samples of them*". On **Monday 1 October**, Fitzalan went ashore where he engaged in various plant collecting and gardening activities and noted that "*there is a tree here very abundant, which bears a very agreeable plum* [100]*. One tree will produce several bushels of these plums, and the wood of it will be found useful for the turner and the engraver, having a grain very much like box... I spent one day here* [near the native wells] *making a garden, where I planted about half a hundred of potatoes, some maize, sorghum, cotton, melon, pumpkin, cabbage, carrot, onion, and some of most European vegetable seeds. I also planted some ginger given me by Mr. Hill for that purpose*".

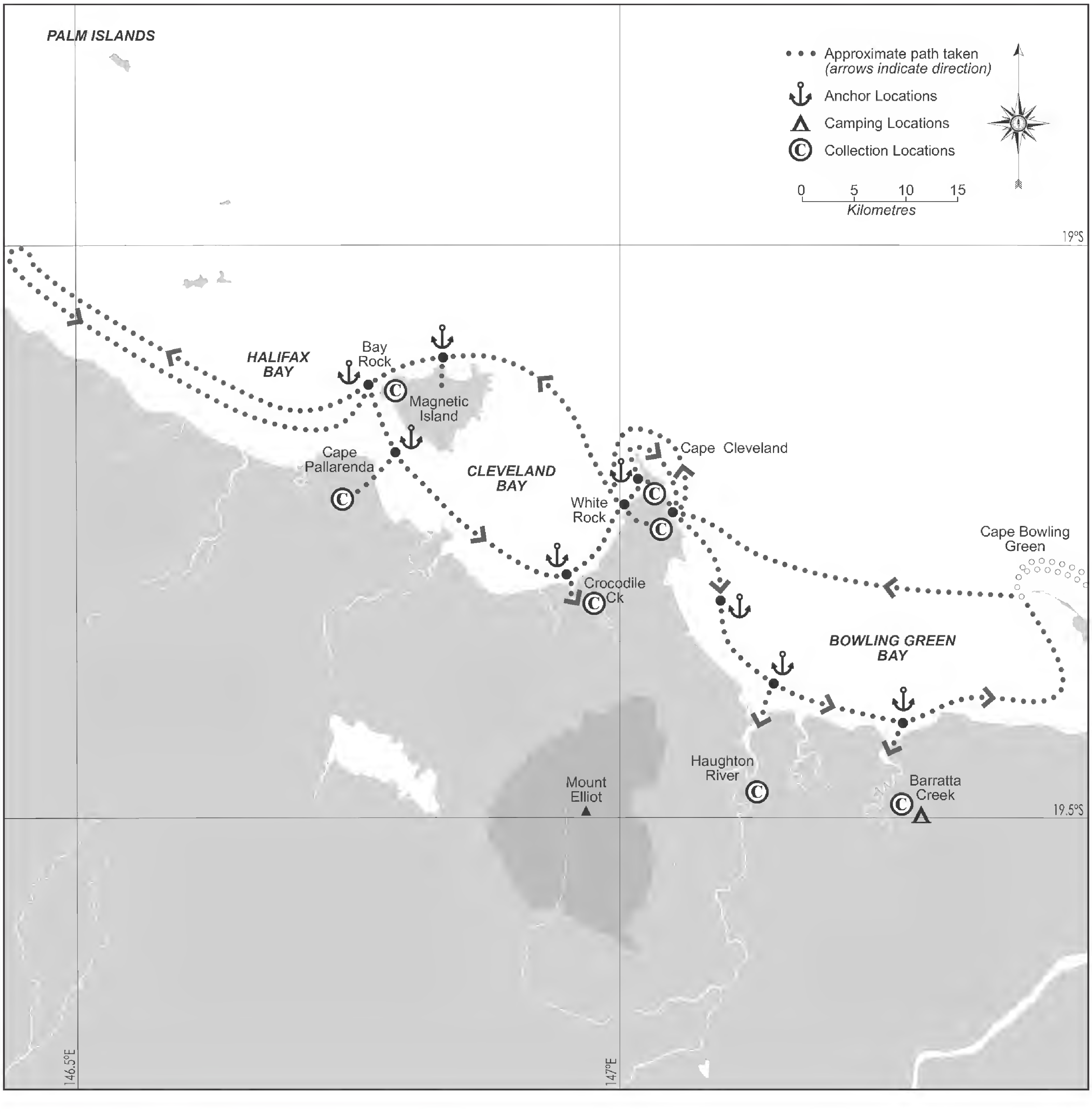


Fig. 8. Map of the approximate paths taken during the Burdekin Expedition, Cape Bowling Green to Halifax Bay, 15–25 September 1860. Prepared by Claire Burton, Cairns Regional Council.

On **Friday 5 October**, Dalrymple (1860) reported that "*by sundown Mr. Fitzallan had completed two gardens*".

> Hill (1860a) listed these species for Port Denison:
>
> *4. Rubiaceae, a noble tree* [101]*, greatly resembling the habit of the Moreton Bay fig, fruit not esteemed. Port Denison.*
>
> *17. Ehretiaceae, a small shrub* [102]*. Port Denison.*
>
> *20. Fabaceae, a handsome spreading tree* [103]*. Port Denison.*
>
> *24. Myrtaceae, a beautiful small tree* [104] *with dense foliage, producing clusters of fruit, not eatable, the wood emits an agreeable aromatic fragrance. Port Denison.*
>
> *31. Sterculiaceae, a beautiful tree* [105]*, particularly when in fruit. Port Denison.*
>
> *32. Rubiaceae, a pretty flowering shrub* [106]*. Port Denison.*
>
> *37. Myrtaceae, a large tree, 80 to 90 feet high* [107]*. Port Denison.*
>
> *38. Myrtaceae, a small tree with dense foliage* [108]*. Port Denison.*
>
> *43. Apocynaceae, a shrub* [109]*, 10 to 12 feet high, flowers sweet scented. Port Denison.*
>
> *48. Ebenaceae, a large growing tree* [110]*, timber, close-grained and firm. Port Denison.*
>
> *52. Rubiaceae, a large shrub* [111]*, with little beauty. Port Denison.*
>
> *55. Moraceae, a climber of robust habit* [112]*. Port Denison.*
>
> *61. Meliaceae, a tree of considerable size* [113]*, with fine spreading branches. Port Denison.*
>
> *73. Orchidaceae, an epiphyte* [114]*, same as No. 72, except that the flowers are yellow. Port Denison.*
>
> *101. Graminaceae, a grass* [115] *of no value for fodder. Port Denison.*
>
> *115. Herbaceous plant* [116]*. Port Denison.*
>
> *124. Fabaceae, a small tree* [117]*. Port Denison.*
>
> *127. Apocynaceae, seeds* [118]*. Port Denison.*
>
> *129. Asclepiadaceae, seeds* [199]*. Port Denison.*
>
> *130. Fabaceae, seeds* [120]*. Port Denison.*

Mueller (1860b) listed these species for Port Denison: *Pisonia aculeata L.* [121] *...Sinclair Island* [Stone Island]. *A robust climbing plant, according to Mr. Fitzalan.*

Derris uliginosa Benth. [122] *....Flowers, according to Mr. Fitzalan, pale pink.*

Guettarda speciosa Linné. [123] *...Port Sinclair* [Port Denison]*...Mr. Fitzalan contends that it forms on the above locality a large tree.*

They departed Port Sinclair [Port Denison] on **Tuesday 9 October**, sailing directly south. There are no records of landfalls or activities for the next nine days. On the morning of **Thursday 18 October**, they arrived at Cape Moreton, and then at Government Wharf, Brisbane at about 11.00 pm of the same day.

Results of Burdekin Expedition

The Burdekin Expedition was one of the first major botanical enterprises in the newly established Colony of Queensland and the results presented a significant milestone in the development of botanical research for the colony. About 140 specimens were collected by Fitzalan during the Expedition. Considering that the Expedition lasted for 57 days, this is a modest number of specimens, averaging only three per day. However, as only 30 days were spent ashore, and many of the landings lasted for no more than a few hours, an average of about six specimens per day was therefore achieved.

The specimens were originally examined by Walter Hill, the Queensland Government Botanist when the Expedition returned to Brisbane. Hill (1860a) provided an annotated list, but only to the designation of family. The specimens were subsequently dispatched to Ferdinand Mueller, the Victorian Government Botanist at the Melbourne Botanic Gardens, and he produced a detailed and thorough botanical treatment (Mueller1860b). Hill did not operate an herbarium in Brisbane whilst he was Queensland Government Botanist (Holland 2005). Mueller also took the opportunity to include summaries of some genera and included descriptions of species that were not actually collected by Fitzalan during the Expedition, but details explaining this were clearly provided by Mueller.

Mueller (1860b) provided annotated descriptions of 88 taxa in his treatment. Of these, 15 were described as new species but only ten pertained directly to the Burdekin Expedition (Table 5). Subsequently, other new species were described from Fitzalan's Burdekin Expedition specimens that Mueller had not included in his initial treatment. A further 16 were described in Bentham's *Flora Australiensis*, 11 in Mueller's *Fragmenta Phytographiae Australiae*, and one each in *Adansonia* and the *Journal de Botanique Néerlandaise* (Table 5). In total, about 40 new taxa were described from Fitzalan's specimens collected on this Expedition. A summary of all the species collected during the Burdekin Expedition is presented in Table 6.

Excursions to Mount Dryander

Three excursions were carried out by Eugene Fitzalan and his companions to Mount Dryander, and are here described on the information that was presented in various reports, and an assessment of the herbarium records in the Royal Botanical Gardens, Melbourne (MEL). The three excursions included:

- Mount Dryander via Port Molle, November 1869 (Anon. [Perceval] 1869): Plant collectors were Fitzalan and/or Frederick Kilner.
- Mount Dryander via Whitsunday Island, June 1872 (Anon. [Kilner] 1872a, 1872b): Plant collectors were Fitzalan and/or Frederick Kilner.

- Mount Dryander via overland approach from the west, July 1872 (Anon. [Fitzalan & Rainbird] 1872): Plant collector was Fitzalan.

Mount Dryander is located about 42 km south-east of Bowen and 16 km west of Airlie Beach and rises to about 800 m elevation. It was named after Jonas Carlsson Dryander (1748–1810) Swedish botanist and librarian for Sir Joseph Banks, by Lieutenant Phillip Parker King RN during the voyage of HM Colonial Cutter *Mermaid*, July 1820. Mount Dryander contains significant areas of low-altitude notophyll vine forest and a considerable number of endemic, rare and threatened, and/or vulnerable species (Thurgate & Maloney 1996).

Mount Dryander via Port Molle, November 1869

Unlike the Burdekin Expedition of 1860 that was organised and funded by the Queensland Government, the Mount Dryander excursion of 1869 has little existing documentation as it was not an official undertaking. Decisions concerning the planning remain unknown. The only published sources of information about the excursion, to my knowledge, include a single newspaper report (Anon. [Perceval] 1869) that was rerun with minor variations in a number of Australian newspapers, and in which it was stated that the explorers went "*in search of objects botanical, zoological, and topographical*". The only record of the botanical activities to be mentioned in this report was that "*the botanist had discovered several new varieties of plants, some of them of great beauty*".

There are about 50 herbarium specimens collected by Fitzalan that can be positively attributed to this excursion as they are either dated, or were cited in the literature of post–1869 but pre–1872, the year of the two succeeding excursions to Mount Dryander (AVH 2014). In addition to the dated specimens there are about 40 to which an approximate date or date-range cannot be applied. Some of these may well have been collected during the 1869 excursion but this is unable to be determined on the present evidence. In addition, there are about 15 species of land snails that were collected by John Rainbird during the excursions. These aspects will be discussed further under the individual excursions or in the conclusion.

The 1869 excursion consisted of six persons:

- Eugene Fitzalan, botanical collector.
- Frederick Kilner (b. ? 1837, Germany; d.? 1905) was the Harbour Master and Sub-collector of Customs at Bowen 1863–1872, and an amateur plant collector with about 230 specimens collected by him, predominantly of marine algae, conserved in MEL, and a few in BRI and NSW. The species *Ochrosia kilneri* F.Muell. (*Neisosperma kilneri* (F.Muell.) Fosberg & Sachet), *Acetabularia kilneri* J.Agardh, *Caulerpa kilneri* J.Agardh (*Caulerpa lentillifera* J.Agardh),*Cladophora kilneri* Sonder and *Desmia kilneri* J.Agardh (*Portieria kilneri* (J.Agardh) P.C.Silva), were named for him.
- John Rainbird (b. 14 July 1817, Blackmore, Essex, England; d. 18 October 1908, Bowen) was a resident of Bowen 1862–1908, and was an amateur naturalist specialising in conchology, ornithology, herpetology and entomology. About 48 malacology collections by Rainbird are conserved in the Australian Museum, Sydney (A. Miller *pers. com.*). The snail *Helix rainbirdii* Cox, 1870 (*Bentosites yulei* Forbes, 1851) was named for him.
- Augustus George Perceval (b. 2 May 1829; d. 19 August 1896) was an accountant, journalist, author (Perceval 1881) and public administrator who resided in Bowen from 1864 to 1873. Perceval was active in public matters and community life at Bowen. In 1868 he was the Secretary of the Bowen Library and Museum; in 1869 was the Honorary Secretary of the Bowen Cemetery; and 1866–1874 worked as a journalist and sub-editor for the *Port Denison Times* [124, 125].
- Two unnamed boat men.

The itinerary described here is taken from a single report in the *Port Denison Times* (Anon. [Perceval] 1869). The tracks taken (Figure 9) were estimated by ascertaining topographical, environmental and geological features that were mentioned and described in the report. Labels and other notes with the botanical collections now conserved in MEL provided only the barest geographical descriptors, such as '*Mt Dryander*' or '*Edgecumbe Bay*', with no indication of elevation, position or precise collection date. Of the specimens that are dated, it appears that dates may have been added later, possibly when they were dispatched from Port Denison or when they arrived at the Melbourne Botanic Gardens, as many of the dates do not coincide with those known for the excursion.

The excursion departed Bowen at about 3.00 pm, on **Monday, 5 November 1869**. An offer was made by Captain Saunders of the Steamer *Tinonee* "*to tow the boat part of the way*". The *Tinonee* was an iron, twin screw steamship of 279 gross tons [253 MT], length of 193 feet 7 inches [59 m], breadth of 21 feet 4 inches [6.5 m] and draft of 10 feet 5 inches [3.2 m] (Hoskin 2007–2009). The steamer arrived at Port Molle at about 8.00 pm of the same day (Figure 10). The excursion party "*was cast adrift*" and "*after a long pull the boat was hauled ashore at the head of a harbour* [Shute Bay] " (but see Blackwood 1997 who proposed that it was Pioneer Bay) where they camped for the night. In the morning "*the tide was a long way out, so they resolved to wait until it came in, and in the meantime to look about them. It was found that the steamer had taken them a good deal too far, and that it would be necessary for them to retrace their steps a considerable distance before they could commence the land part of their journey*". During the day of **Tuesday, 6 November**, they rowed northward "*on round*

Table 5. Type specimens collected by Eugene Fitzalan during the Burdekin Expedition, August-October 1860. Original species names are retained and the currently used name follows in parentheses. Collections list the location and the specimens relevant to typification, but the status of the typification is not provided as it is beyond the scope of this work. The publication details of the protologue are provided. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Taxon	Collections	Publication
Acacia leptostachya Benth.	Port Denison, 1860, *Fitzalan*: BM000796781, BM000796782, BM000796784, K000806623, MEL2078167, MEL2078169, NSW183648	*Fl. Austral.* 2: 406 (1864)
Alyxia thyrsiflora Benth. (*Alyxia spicata* R.Br.)	Burdekin River & Port Denison, 1860, *Fitzalan*; K000894092, W0049218	*Fl. Austral.* 4: 309 (1868)
Antidesma parvifolium Thwaites & F.Muell.	Edgecumbe Bay & Port Denison, 1860, *Fitzalan*; MEL0251036, MEL0251037, MEL0251054, MEL0515968– MEL0515971, MEL0515973– MEL0515975	*Fragm.* 4(26): 86 (1864)
Atylosia marmorata Benth. (*Cajanus marmoratus* (Benth.) F.Muell.	Port Denison, 1860, *Fitzalan*; MEL0091579	*Fl. Austral.* 2: 263 (1864)
Atylosia pluriflora F.Muell. ex Benth.	Burdekin Expedition, 1860, *Fitzalan*; K, MEL [specimens not located]	*Fl. Austral.* 2: 264 (1864)
Cajanus confertiflorus F.Muell.	Magnetic Island, 1860, *Fitzalan*; K000279381, MEL0061471, MEL0061472	*Rep. Burdekin Exped.* 9 (1860)
Cajanus grandifolius F.Muell. (*Cajanus reticulatus* var. *grandifolius* (F.Muell.) Maesen	Cape Upstart, 1860, *Fitzalan*; MEL0061459, MEL0061460	*Rep. Burdekin Exped.* 9 (1860)
Canarium australianum F.Muell.	Burdekin River Estuary & Cape Cleveland, 1860, *Fitzalan*; MEL2290901	*Fragm.* 3(17): 15 (1862)
Canthium lamprophyllum F.Muell. (*Psydrax lamprophylla* (F.Muell.) Bridson	1860, Fitzalan; [no relevant specimens]	*Fragm.* 2(15): 133 (1861)
Capparis ornans F.Muell. ex Benth.	Port Denison, 1860, *Fitzalan*; K000651064, MEL0590420 – MEL0590422	*Fl. Austral.* 1: 95 (1863)
Cartonema brachyantherum Benth.	Port Denison, 1860, *Fitzalan*; MEL0247909	*Fl. Austral.* 7: 92 (1878)
Cassia acclinis F.Muell. (*Senna acclinis* (F.Muell.) Randell	Edgecumbe Bay, 1860, *Fitzalan*; MEL2071409	*Fragm.* 4(24): 13 (1863)
Cochlospermum gillivraei Benth.	Cape Cleveland, Cape Upstart & Port Denison, 1860, *Fitzalan*; K000675859, MEL0081431, MEL0081432– MEL0081440	*Fl. Austral.* 1: 106 (1863)
Croton arnhemicus var. *urenifolius* Baill.	Edgecumbe Bay & Port Denison, 1860, *Fitzala*n; MEL0231243, MEL0231249, MEL0231251	*Adansonia* 6: 300 (1866)
Cupania punctulata F.Muell. (*Lepiderema punctulata* (F.Muell.) Radlk.)	Edgecumbe Bay, 1860, *Fitzalan*; MEL1586087, MEL1586089	*Fragm.* 3(17): 12 (1862)
Cyanospermum australe F.Muell. [Australian Plant Census excluded name]	1860, *Fitzalan*; [no relevant specimens]	*Rep. Burdekin Exped.* 10 (1860)
Elaeodendron melanocarpum F.Muell.	Port Denison, 1860, *Fitzalan*; BR6981228, MEL2136469	*Fragm.* 3(20): 62 (1862)
Eucalyptus drepanophylla Benth. (*Eucalyptus crebra* F.Muell.)	Burdekin Expedition, 1860, *Fitzalan*; G00227657, K000347645, MEL0073656	*Fl. Austral.* 3: 221 (1867)
Eugenia carissoides F.Muell.) (*Eugenia reinwardtiana* (Blume) DC)	Port Denison, 1860, *Fitzalan*; K000821554, MEL0060216, MEL0060221	*Fragm.* 3(22): 130 (1863)
Ficus fitzalanii Miq. (*Ficus opposita* Miq.)	Cape Cleveland, 1860, *Fitzalan*: MEL0239354	*J. Bot. Néerl.* 1: 242 (1862)
Ficus platypoda var. *petiolaris* Benth. (*Ficus rubiginosa* Desf. Ex Vent.)	Cape Cleveland & Port Denison, 1860, *Fitzalan*; MEL0239504, MEL0239478	*Fl. Austral.* 6: 169 (1873)
Gardenia fitzalanii F.Muell. (*Atractocarpus fitzalanii* (F.Muell.) Puttock)	Cape Upstart, Halifax Bay & Magnetic Island, 1860, *Fitzalan*; MEL0598569	*Rep. Burdekin Exped.* 12 (1860)
Grewia orientalis var. *latifolia* Benth. (*Grewia oxyphylla* Burret)	Port Denison, 1860, *Fitzalan*; MEL1599178–MEL1599182	*Fl. Austral.* 1: 270 (1863)
Hoya dalrympleana F.Muell. (*Hoya australis* R.Br. ex J. Traill var. *australis*)	Cape Cleveland, 1860, *Fitzalan*; MEL0073610	*Rep. Burdekin Exped.* 16: (1860)
Indigofera pratensis F.Muell.	Port Denison, 1860, *Fitzalan*; MEL 586229	*Rep. Burdekin Exped.* 10 (1860)
Ixora thozetiana F.Muell. (*Aidia racemosa* (Cav.) Tirveng.)	Port Denison, 1860, *Fitzalan*; K000761786, HAL0114223, MEL2266019, MEL2266461	*Fragm.* 2(15): 132 (1861)
Labichea nitida Benth.	Burdekin River estuary, 1860, *Fitzalan*; MEL0640529	*Fl. Austral.* 2: 293 (1864)
Lagunaria patersonia var. *bracteata* Benth. (*Lagunaria queenslandica* Craven)	Port Denison, 1860, *Fitzalan*; K000659929, MEL2223634, MEL2223638	*Fl. Austral.* 1: 218 (1863)
Leptosema chambersii F.Muell. (*Brachysema chambersii* (F.Muell.) Benth.	Burdekin Expedition, 1860, *Fitzalan*; [no specimens located]	*Rep. Burdekin Exped.* 8 (1860)
Leptosema oxylobioides F.Muell. (*Brachysema oxylobioides* (F.Muell.) Benth.	Port Denison, 1860, *Fitzalan*; [no specimens located]	*Rep. Burdekin Exped.* 8 (1860)

Table 5. cont.

Taxon	**Collections**	**Publication**
Loranthus vitellinus F.Muell. (*Dendrophthoe vitellina* (F.Muell.) Tiegh.)	Magnetic Island, 1860, *Fitzalan*; HAL0110273, MEL0591630, MEL2237734, MEL2237735	*Rep. Burdekin Exped.* 12 (1860)
Myrcia australasica F.Muell.(*Memecylon umbellatum* Burm.f., excluded name)	Magnetic Island, 1860, *Fitzalan*; [no specimens located]	*Rep. Burdekin Exped.* 7 (1860)
Neptunia gracilis var. *major* Benth. (*Neptunia major* (Benth.) Windler)	Bowling Green Bay & Burdekin River, 1860, *Fitzalan*; MEL0596305	*Fl. Austral.* 2: 300 (1864)
Panax macrosciadeus F.Muell. (*Mackinlaya macrosciadea* (F.Muell.) F.Muell.)	Cumberland Islands & Port Molle, 1860, *Fitzalan*; MEL0247913	*Fragm.* 2(14): 108 (1860)
Polycarpaea synandra var. *densiflora* Benth. (*Polycarpaea spirostylis* var. *densiflora* (Benth.) Pedley)	Port Denison, 1860, *Fitzalan*; K000723256, MEL0049116	*Fl. Austral.* 1: 165 (1863)
Psychotria fitzalanii Benth.	Port Molle, 1860, *Fitzalan*; K000777505	*Fl. Austral.* 3: 428 (1867)
Ratonia distylis Benth. (*Arytera distylis* (Benth.) Radlk.)	Port Denison, 1860, *Fitzalan*; MEL0108778	*Fl. Austral.* 1: 462 (1863)
Terminalia melanocarpa F.Muell.	Edgecumbe Bay, 1860, *Fitzalan*; MEL2245930, MEL2245931, MEL2245934	*Fragm.* 3(20): 92 (1862)
Uraria cylindracea Benth. (*Uraria lagopodioides* (L.) Desv. Ex Dc)	Port Denison, 1860, *Fitzalan*; MEL2064211	*Fl. Austral.* 2: 237 (1864)
Uvaria heteropetala F.Muell. (*Meiogyne heteropetala* (F.Muell.) D.C.Thomas, Chaowasku & R.M.K.Sanders)	Cumberland Islands, 1860, *Fitzalan*; MEL2064812–MEL2064816	*Fragm.* 3(17): 1 (1862)

two or three headlands" and finally they entered "*the head of a very nice harbour* [Woodwark Bay], *with a fine stretch of sandy beach*". Before sunset, they climbed a saddle on the peninsula between Woodwark Bay and Double Bay [east branch] "*to take observations for the next day's trip*" and from this point could observe that "*a spur evidently led direct up to the main ridge of Mount Dryander*". Camp for the night of Tuesday 6 November was set up on a sandy beach at the head of Woodwark Bay.

On the morning of **Wednesday 7 November**, the walking party, consisting of Fitzalan, Kilner, Rainbird and Perceval, started with the goal of ascending Mount Dryander. In the meantime, the boat proceeded northward to the adjacent Double Bay [east branch], where the walking party would rendezvous following their ascent and descent of the mountain. Soon after commencement, the walking party had "*some little difficulty in wading across an abominable mud flat* [126]" at the head of Double Bay [east branch] in an attempt to shorten the distance to a ridge that they sought to begin their ascent. At the "*first stream they came to*" after crossing the mudflats "*they bogied and breakfasted*". Following on, they walked "*through several miles of beautiful country*" toward the mountain and "*came to a convenient place for commencing the ascent of the main range of Mount Dryander*". The climb started "*through open forest* [127] *for some two-thirds of the ascent until they came to a dense scrub* [128]" and they decided to leave their swags there. Perceval remained with the swags whilst Fitzalan, Kilner and Rainbird made the ascent to the top of the main ridge. At this point, Perceval inscribed a large ligatured AP "*on a gum tree facing the entrance to the scrub*". The ascending party continued along the ridge for some distance, and concluded this section by "*marking a tree at the furthest point*". They did not proceed to the summit or "*get onto the high peaks that rise above the ridge*" as cloud had begun to envelope the higher parts and obtaining views of the surrounding country was deemed to be impossible. The party returned to their swags, and they "*descended to a bay in the low range of hills to which we have before alluded as separating Port Dalrymple from its twin harbour*", i.e. the east branch of Double Bay from the west branch of Double Bay. Following a prearranged smoke signal, the party re-joined the boat and made camp for the night of 7–8 November somewhere on the inner shores of Double Bay [east branch].

On the morning of **Thursday 8 November**, the walking party "*started for a course across a neck of land to the twin harbour* [Double Bay, west branch], *and thence over some few miles of the country at the head of it*". They ventured no more than "*a mile or two from the beach*". During the walk they observed, from a distance "*a pass* [Earlando Gap] *through the mountains round the northern foot of Mount Dryander*". After reaching the northern limit of their exploration, they returned to the camp of the previous night at Double Bay [east branch], and at about 1.00 pm departed for Bowen. The homeward journey north was much slowed as it was "*against a dead head wind nearly the whole way*". It is assumed that three camps were made during the return journey, but their locations, and any botanical activities, were not recorded. They arrived at Bowen at about 11.00 pm on the evening of **Monday 12 November**.

Mount Dryander via Whitsunday Island, June 1872

The itinerary presented here is taken from the report written by Kilner (Anon. [Kilner] 1872a, 1872b). The aim of the excursion was to "*make a short voyage of discovery to*

Whitsunday Islands, returning to Mount Dryander and the inner passage to Bowen". The party consisted of five persons:

- Frederick Kilner, leader and author of the report.
- Eugene Fitzalan, botanical collector.
- John Rainbird, conchologist.
- Rev. J.K. Black, A.M., [Church of England, Trinity Church, Bowen] general collector.
- An Aborigine named Jimmy.

On **Monday 2 June 1872,** their four-oared boat was hoisted onto the Steamer *Tinonee* at Port Denison. They departed, rounded Cape Gloucester where they had their "*first view of the graceful Hoop Pine* [129] *(Araucaria glauca) which grows rather thickly here in a shady gorge sheltered by two spurs that run down to the sea*". They passed Hook Island and Dent Island, and when near Whitsunday Island their boat was lowered and they rowed ashore (Figure 10). They landed near Fitzalan Point in a sheltered bay where the "*atmosphere was here filled with the most fragrant perfumes exhaled from a tree resembling the Bauhinia* [130], *in full bloom, beneath the outspreading branches and broad shady leaves of which we pitched out tent*" and camped for the night at a location that was "*fringed with a coral reef; behind us a luxuriant forest of towering pines of immense growth, covering the higher parts of the island*". To the west was an opening to Long Island and with views extending toward Port Molle.

After breakfast on the morning of **Tuesday 3 June**, they walked to the "*Falls*" near Fitzalan Point. Blackwood (1997)

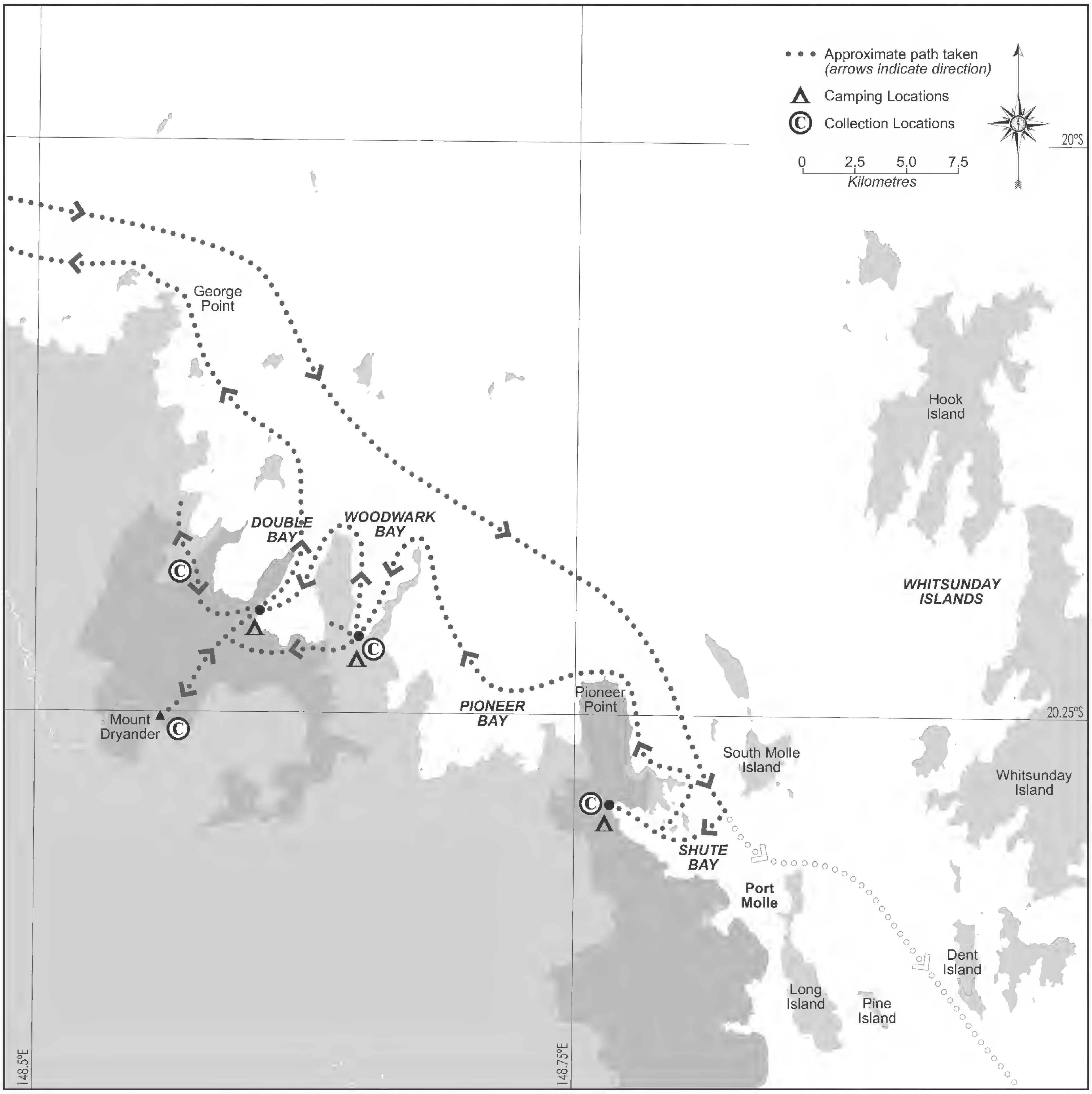


Fig. 9. Map of the approximate paths taken during the excursion to Mount Dryander, 5–12 November 1869. Prepared by Claire Burton, Cairns Regional Council.

Table 6. List of species collected by Eugene Fitzalan during the Burdekin Expedition, 1860. The list is derived from herbarium record data and published accounts. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Lady Elliot Island

Phajus australis F.Muell. (*Phaius australis* F.Muell.)

Percy Island No. 1 [South Island]

Calophyllum inophyllum L.
Dendrobium undulatum R.Br.(*Dendrobium discolor* Lindl.)
Morinda citrifolia L.
Plectranthus parviflorus Willd.
Tournefortia orientalis R.Br. (*Heliotropium sarmentosum* (Lam.) Craven)
Turraea pubescens Hell.

Cumberland Islands

Araucaria cunninghamii Mudie var. *cunninghamii*
Brassaia actinophylla Endl. (*Schefflera actinophylla* (Endl.) Harms)
Callitris verrucosa (A.Cunn. ex Endl.) F.Muell. (*Callitris intratropica* R.T.Baker & H.G.Sm.)
Colubrina asiatica (L.) Brongn.
Lotus australis Andrews
Panax macrosciadeus F.Muell. (*Mackinlaya macrosciadea* (F.Muell.) F.Muell.)
Petalostigma quadriloculare F.Muell.
Uvaria heteropetala F.Muell. (*Meiogyne heteropetala* (F.Muell.) D.C.Thomas, Chaowasku & R.M.K.Saunders)

Port Molle [Long Island]

Brassaia actinophylla Endl. (*Schefflera actinophylla* (Endl.) Harms)
Canthium lamprophyllum F.Muell. (*Psydrax lamprophylla* (F.Muell.) Bridson)
Cissus opaca F.Muell. (*Clematicissus opaca* (F.Muell.) Jackes & Rossetto)
Crotalaria mitchellii Benth. (*Crotalaria novae-hollandiae* DC. var. *novae-hollandiae*)
Euphorbia hypericifolia L.
Glycosmis subvelutina F.Muell. (*Micromelum minutum* (G.Forst.) Wight & Arn.)
Helichrysum bracteatum (Vent.) Andrews (*Xerochrysum bracteatum* (Vent.) Tzvelev)
Labichea rupestris Benth.
Melia azederach L.
Panax macrosciadeus F.Muell. (*Mackinlaya macrosciadea* (F.Muell.) F.Muell.)
Pogonolobus reticulatus F.Muell. (*Coelospermum reticulatum* (F.Muell.) Benth.)
Psychotria fitzalanii Benth.
Sophora tomentosa L.
Tabernaemontana orientalis R.Br.

Edgecumbe Bay

Antidesma parvifolium Thwaites & F.Muell.
Cassia acclinis F.Muell. (*Senna acclinis* (F.Muell.) Randell
Croton arnhemicus var. *urenifolius* Baill.
Cupania punctulata F.Muell. (*Lepiderema punctulata* (F.Muell.) Radlk.)
Terminalia melanocarpa F.Muell.

Port Sinclair [Bowen], Mount Gordon

Brachychiton ramiflorum R.Br. (*Brachychiton paradoxus* Schott & Endl.)
Dilivaria ilicifolia (L.) Pers. (*Acanthus ilicifolius* L.)

Cape Upstart

Acacia simsii A.Cunn. ex Benth.
Bursaria spinosa Cav.
Cycas media R.Br.
Gardenia fitzalanii F.Muell. (*Atractocarpus fitzalanii* (F.Muell.) Puttock)
Gardenia ochreata F.Muell. (*Larsenaikia ochreata* (F.Muell.) Tirveng.)
Melaleuca leucadendron L.f.
Pimelea collina R.Br. (*Pimelea linifolia* var. *collina* (R.Br.) Threfall)
Trichodesma zeylanicum (Burm.f.) R.Br.
Tristania conferta R.Br. (*Lophostemon confertus* (R.Br.) Peter G.Wilson & J.T.Waterh.)

Cape Upstart – Station Hill [Signal Hill*]

Cajanus grandifolius F.Muell. (*Cajanus reticulatus* var. *grandifolius* (F.Muell.) Maesen)
Tristania conferta R.Br. (Lophostemon confertus (R.Br.) Peter G.Wilson & J.T.Waterh.)

* Signal Hill appears to be a typographical error for Station Hill, in Mueller's Essay.

Magnetical Island [Magnetic Island]

Myrcia australasica F.Muell. (*Memecylon umbellatum* Burm.f.)
Cajanus confertiflorus F.Muell.
Canthium coprosmoides F.Muell. (*Cyclophyllum coprosmoides* (F.Muell.) S.T.Reynolds & R.J.F.Hend.)
Dampiera ferruginea R.Br.
Tristania conferta R.Br. (*Lophostemon confertus* (R.Br.) Peter G. Wilson & J.T.Waterh.)
Gardenia fitzalanii F.Muell. (*Atractocarpus fitzalanii* (F.Muell.) Puttock)
Loranthus vitellinus F.Muell. (*Dendrophthoe vitellina* (F.Muell.) Tiegh.)

Halifax Bay

Gardenia fitzalanii F.Muell. (*Atractocarpus fitzalanii* (F.Muell.) Puttock)
Pariti tiliaceum (L.) A.St.-Hil. (*Hibiscus tiliaceus* L.)

Cleveland Bay

Maba geminata R.Br. (*Diospyros geminata* (R.Br.) F.Muell.)
Melhania oblongifolia F.Muell.
Sida indica L. (*Abutilon indicum* (L.) Sweet)

Cape Cleveland

Bauhinia hookeri F.Muell.
Celastrus dispermus F.Muell. (*Denhamia disperma* (F.Muell.) M.P.Simmons)
Clerodendrum inerme (L.) Gaertn.)
Conospermum linifolium A.Cunn. ex Meisn. (*Conospermum taxifolium* C.F.Gaertn.)
Crotalaria laburnifolia L.
Dipodium punctatum (Sm.) R.Br.
Ficus fitzalanii Miq. (*Ficus opposita* Miq.)
Ficus platypoda var. *petiolaris* Benth. (*Ficus rubiginosa* Desf. ex Vent.)
Hoya dalrympleana F.Muell. (*Hoya australis* R.Br. ex J.Traill subsp. *australis*)
Persoonia falcata R.Br.
Pseudanthus pimeleoides Sieber ex Spreng.
Tecoma australis R.Br. (*Pandorea pandorana* (Andrews) Steenis)

Bowling Green Bay

Statice australis Spreng. (*Limonium australe* (R.Br.) Kuntze)
Neptunia gracilis var. *major* Benth. (*Neptunia major* (Benth.) Windler)

Burdekin River Estuary

Brassaia actinophylla Endl. (*Schefflera actinophylla* (Endl.) Harms)
Canarium australianum F.Muell.

Labichea nitida Benth.
Neptunia gracilis var. *major* Benth. (*Neptunia major* (Benth.) Windler)

Port Sinclair [Bowen), Sinclair Island [Stone Island]

Guilandina bonduc L. (*Caesalpinia bonduc* (L.) Roxb.)
Morinda citrifolia L.
Pisonia aculeata L.
Scaevola suaveolens R.Br. (*Scaevola calendulacea* (Andrews) Druce)

Port Sinclair/Port Denison [Bowen]

Abrus precatorius L.
Acacia farnesiana (L.) Willd.
Acacia leptostachya Benth.
Alyxia spicata R.Br.
Antidesma parvifolium Thwaites & F.Muell.
Atylosia marmorata Benth. (*Cajanus marmoratus* (Benth.) F.Muell.)
Blumea wightiana DC. (*Blumea mollis* (D.Don) Merr.)
Busbeckia corymbiflora F.Muell. (*Capparis lucida* (Banks ex DC.) Benth.
Canthium lamprophyllum F.Muell. (*Psydrax lamprophylla* (F.Muell.) Bridson)
Capparis ornans F.Muell. ex Benth.
Cartonema brachyantherum Benth.
Careya arborea Roxb. (*Planchonia careya* (F.Muell.) R.Knuth)
Cochlospermum gregorii F.Muell.
Cochlospermum gillivraei Benth.
Croton arnhemicus var. *urenifolius* Baill.
Derris uliginosa Benth. (*Derris trifoliata* Lour.)
Eucalyptus drepanophylla Benth. (*Eucalyptus crebra* F.Muell.)
Eucalyptus platyphylla F.Muell.
Elaeodendron melanocarpum F.Muell.
Eugenia carissoides F.Muell. (*Eugenia reinwardtiana* (Blume) DC.)
Ficus platypoda var. *petiolaris* Benth. (*Ficus rubiginosa* Desf. ex Vent.)
Grewia orientalis var. *latifolia* Benth.
Guettarda speciosa L.
Indigofera pratensis F.Muell.
Ixora thozetiana F.Muell. (*Aidia racemosa* (Cav.) Tirveng.)
Lagunaria patersonia var. *bracteata* Benth. (*Lagunaria queenslandica* Craven)
Leptosema chambersii F.Muell. (*Brachysema chambersii* (F.Muell.) Benth.)
Leptosema oxylobioides F.Muell. (*Brachysema oxylobioides* (F.Muell.) Benth.)
Lippia nodiflora Rich. (*Phyla nodiflora* (L.) Greene)
Melaleuca leucadendra (L.) L.
Owenia cerasifera F.Muell. (*Pleiogynium timorense* (DC.) Leenh.)
Polycarpaea synandra var. *densiflora* Benth. (*Polycarpaea spirostylis* var. *densiflora* (Benth.) Pedley)
Ratonia distylis Benth. (*Arytera distylis* (Benth.) Radlk.)
Saccharum fulvum R.Br. (*Eulalia aurea* (Bory) Kunth)
Sterculia quadrifida R.Br.
Tournefortia argentea L.f. (*Heliotropium foertherianum* Diane & Hilger
Uraria cylindracea Benth. (*Uraria lagopodioides* (L.) Desv.
Xerotes multiflora R.Br. (*Lomandra multiflora* (R.Br.) Britten

Burdekin Expedition – location not specified

Atylosia pluriflora F.Muell. ex Benth.
Canavalia obtusifolia (Lam. DC. (*Canavalia rosea* (SW.) DC.)
Cyanospermum australe F.Muell.
Eucalyptus drepanophylla Benth. (*Eucalyptus crebra* F.Muell.)
Lactaria calocarpa (Hassk.) Hassk. (*Ochrosia elliptica* Labill.)

proposed that the “*Falls*” are on a stream that discharges into the ocean to the east of Fitzalan Point. On the way they “*passed through a peculiar kind of grass* [131] *of a very fattening nature for cattle, that never grows rank and is not to be met with on the mainland*”. Here the stream of crystal clear water runs through a channel of solid rock, and descends into cascades and falls into large rocky basins. The “*borders of this stream clothed with pines, orchids, ferns, and gigantic creepers …high up on its sloping side is the Cassia (elongata)* [132] *a fragrant flowering tree with blossoms hanging in rich clusters like the English Laburnum* [133]”. They ascended to the summit of a hill immediately behind the beach, from which they obtained views of the “*peaks of Pentecost, the rough outline of the crag called the Lion, the numerous islands…some covered with pines and Kennedy Beech (Argyrodendron trifoliatum)* [134], *intersected with running creeks lined with Palms (Seaforthia* [135] *and Kentia Forsteriana* [136]*), while several were covered with grass of a bright green from which one is called Green Island* [Lindeman Island?]”. During the ascent “*one of our party… caught hold of the stinging nettle (Urtica -------)* [137], *and the pain was so excruciating*”. On returning to camp “*we brought back a large number of young pines and also some seed… land shells we found here…Helix maclayi* [138], *H. pachystyla* [139], *H. coxeni* [140], *black H. o'connellii* [141] *and Pupina* [142]”.

On **Wednesday 4 June,** they departed Whitsunday Island. Heading west, they sailed across an open channel and passed near a bare rocky island without vegetation [Pelican Island?] on the approach to Long Island and Pine Island. This island was noted as “*a favourite resort of sea-birds of various kinds, where in the proper season a great variety of eggs may be procured*”. They crossed the channel and sailed into a bay of the next ‘green’ island [South Molle Island?] where they landed and “*spent an hour in adding to our collection a number of shells chiefly obtainable here (Helix cerata)* [143], *some pines, palms (Kentia forsteriana)* [144] *and palm seeds… also fortunate in getting several Umbrella Trees (Brassice actinophyllum)* [145], *and a giant bean hanging from the tops of trees, in a pod as much as five feet in length, produced by a creeper (Sp. Cassia)* [146]*…the beans are a subject of great attraction to bushmen as matchboxes*”. From here they carried along the coast off Molle Island [South Molle Island or North Molle Island] and entered an unnamed bay [Pioneer Bay] that was bounded by Port Molle Ranges [Conway Range] on the east and Mount Dryander on the west. They were unable to land as it was too shallow, and rowed on to Port Dalrymple [Double Bay, east branch] where they made camp for the night.

On the morning of **Thursday 5 June**, they started for Mount Dryander which was about 2 miles [3.2 km] away, passing through a plain with good soil and luxuriant grass and reached a stream of permanent water [unnamed]. They began to ascend via the stream which had a broad and stony watercourse. In the stream they “*found the seeds in long pods of the Cassia* [147] *(elongata) evidently washed down from the mountain, and the palm (Seaforthia)* [148] *was of striking luxuriance*”. During the ascent they “*met with a rare species of fig tree (Ficus)* [149], *evidently the same as* *that described by Mr Guilfoyle…as the Banyan Tree…parts of the trunk grow up from the branching roots, standing out from the base like walls, and for shade and shelter the tree is unequalled. Further up we came upon a splendid specimen of the flame tree (Brachychiton acerifolia)* [150]*; when young it resembles the Bottle Tree (sterculia) in appearance…when in blossom is covered with a mass of gorgeous red flowers, from which it takes its name*". After a rapid ascent, they struck a perpendicular face of solid rock that extended a long distance round on both sides and formed a barrier to further progress. They estimated that this location was about half way up the mountain. They began the descent from here, but "*before doing so Mr. F. clambered up a steep rock and secured the only specimen we saw on our journey of a very rare orchid (Dendrobium speciosum)* [151]*. So far as we are aware it is only to be found in one other place in this neighbourhood, viz. in an inaccessible part of Roma Peak* [152]". At this location, the "*trees here were covered with orchids and ferns…as many as a dozen various species clustered on one tree (Adiantum* [153]*, Asplenium* [154]*, Pteris* [155]*, Ophioglossum* [156]*, etc.)*". In addition to the plants, there were "*several water beetles and snakes of rare kinds, and many varieties of shells (Vitrina superba* [157]*, H. coxeni* [158]*, H. inforius* [159]*, H. cunninghamii* [160]*, and H. rainbirdii* [161]*). One of these was named after its discoverer, our companion Mr. Rainbird*". Following their descent, they reached their camp at sunset.

On the morning of **Friday 6 June**, they commenced their return to Port Denison. The journey took them past Grassy Island and Gumbrell Island, round George Point and past Saddleback Island and into the Gloucester Passage. Taking

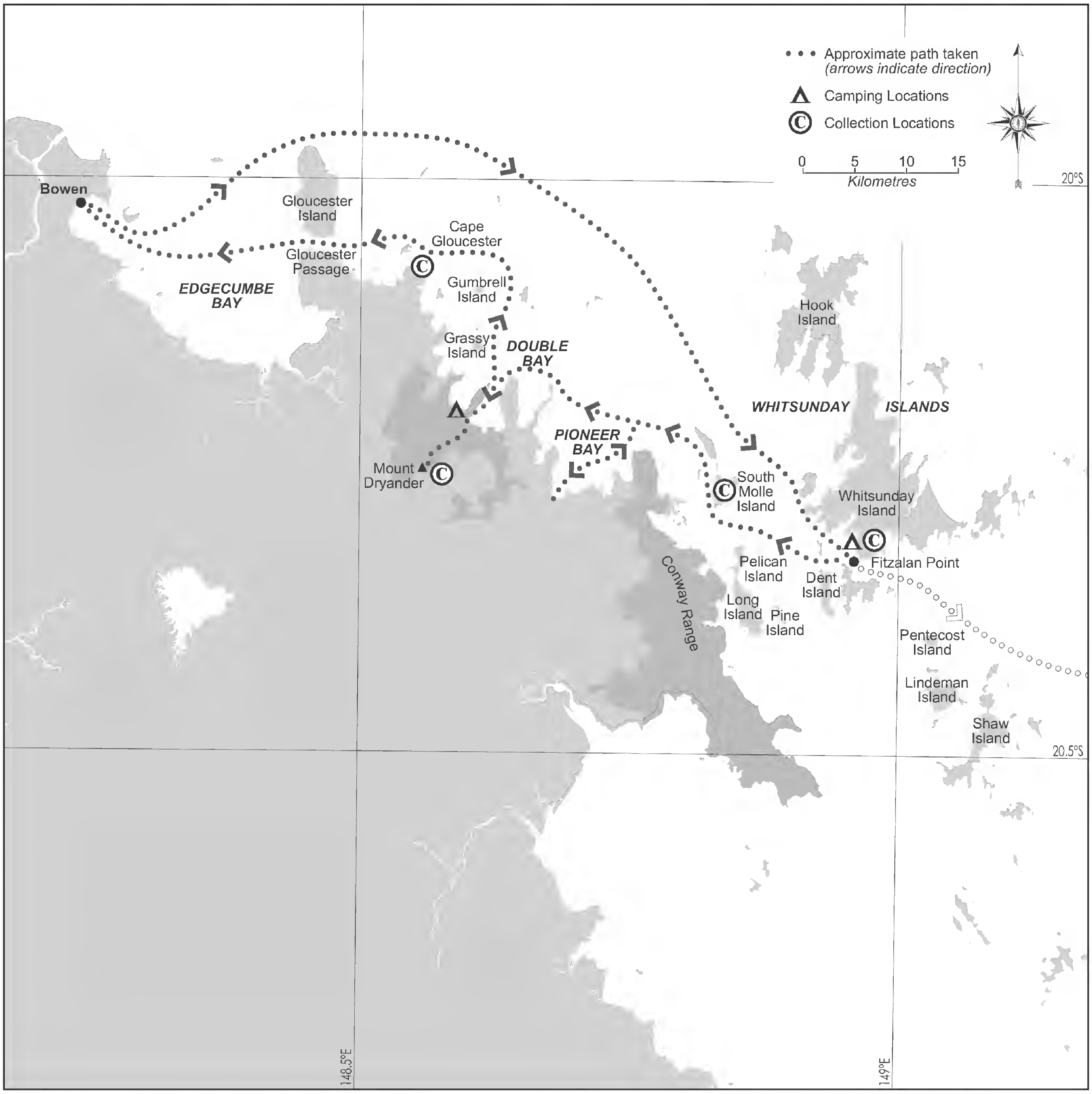


Fig. 10. Map of the approximate paths taken during the excursion to Mount Dryander, 2–6 June 1872. Prepared by Claire Burton, Cairns Regional Council.

the opportunity, they landed briefly after lunch at Gloucester Point "*where a few shells (Helix kilneri)* [162] *were procured*". Recommencing, they travelled via the inner passage [Gloucester Passage] into Edgecumbe Bay, and reached Bowen on the evening of the same day.

Mount Dryander via overland approach, July 1872

One month after visiting Mount Dryander in June 1872, Fitzalan again joined with John Rainbird, and another unnamed companion [not Frederick Kilner], on a third excursion to Mount Dryander, but this time following an overland route starting on horseback (Anon. [Fitzalan & Rainbird] 1872). On the morning of **Monday 2 July 1872**, they left Bowen with the aim "*to stand on the top of Mount Dryander*". On the two previous attempts to reach the summit of Mount Dryander, Fitzalan and his party were not successful because of adverse weather conditions and difficult terrain. This attempt was to be from the west, and during a time of the year when weather was usually fine and mild. There was now a road heading south from Bowen toward Proserpine, completed about 1867 (Port Denison Almanac 1867) and this would have been taken for the first section of the excursion. By midday they had reached Glencoe, Adelaide Point "*where we were hospitably entertained and liberally supplied by Mr MacDonald* [163]". This halt would have been at the homestead of John Graham MacDonald at Adelaide Point, which was about 13 km south of Bowen (Figure 11). Adelaide Point was named for MacDonald's wife Adelaide Mary Anne Amelia MacDonald (née Graham), and the house and garden were considered to be the finest in north Queensland at that

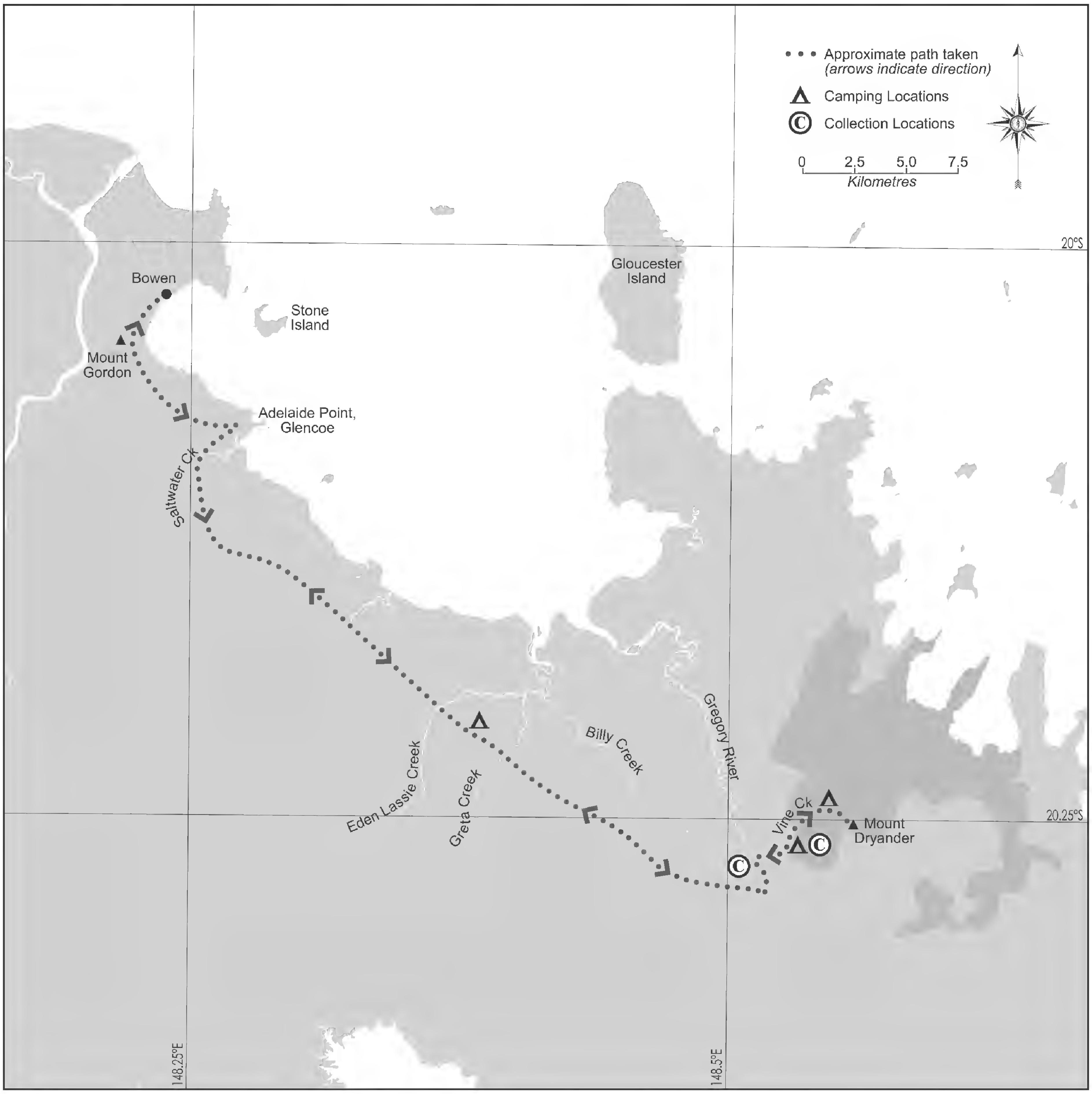


Fig. 11. Map of the approximate path taken during the excursion to Mount Dryander, 2–5 July 1872. Prepared by Claire Burton, Cairns Regional Council.

time (Pike 1996). Soon after leaving Glencoe, they crossed Saltwater Creek [Duck Creek] and then camped for the night between Longford [Eden Lassie Creek] and Gretta [Greta] Creek. They noted “*an abundance of wild pigs…one so formidable in size…we should have thought twice before firing at him*”.

On the morning of **Tuesday 3 July** they crossed Billy Creek, and then came to Gregory River which was “*lined on both sides with a narrow fringe of thick scrub* [164]”. They ascertained that they were below the ‘falls’, and went along the banks of the Gregory River for about 4 miles [6.4 km], and crossed it near “*a good hut, erected by Messrs. Eymer and Corkhill*”. They proceeded on to Vine Creek, at the base of the mountain, and made camp for the night. At this location they noted that “*there is a tree* [165] *to be met with here in considerable quantities remarkable for its fibre producing qualities*”.

Early on the morning of **Wednesday 4 July**, they “*strolled along the creek* [Vine Creek] *and were delighted to discover some rare specimens of a handsome long-leaved orchid (Cymbidium)* [166]. *The Stag-Horn* [167] *and Bird’s-nest ferns* [168] *clustered round the palms presented a beautiful contrast to the fine dark coloured Acacia (angustifolius)* [169] *with which most of the creeks were bordered*”. At this location, Rainbird collected a specimen of “*a handsome shell (Helix murina)* [170]”. Soon after, they commenced the ascent of Mount Dryander, intending to spend the night on the summit. The ascent was “*extremely easy…by the route we adopted*”. They noted the presence of “*tall tapering pines* [171], *interspersed with the Beech* [172], *Fig* [173], *Umbrella* [174] *and Flame trees* [175]”. In addition to the flora, their “*attention was fully occupied with the variety of land shells*”. As they ascended, they collected the “*most beautiful but the most fragile shell to be met with in these parts (Vitrina superba)* [176]”, and “*came upon two of the largest shells we have so far found in northern Queensland (H. Cunninghamii* [177] *and H. Inforius* [178])”. They also “*met with another shell (Balea australis)* [179] *found by McGillavray at Port Molle*”. As they gained altitude their water bags broke because of the strain put on them by brushing against the vegetation, and in particular getting entangled in “*the most formidable creeping vine we have ever met with, usually known as “the lawyer”* [180]. *It is in its earlier career a most graceful looking shrub, like the cocoa-nut, but its stalks, resembling sugar cane, are covered with a formidable set of spines*”. Accordingly, without water, they had to abandon the idea of spending the night on the summit. Nevertheless, they were able to reach the summit where they “*obtained an abundant supply of other varieties (Vittaria elongata* [181], *Polypodium tenellum* [182], *lanceolata* [183], *Pteris crenata* [184], *Davallia elegans* [185]*and Asplenium polypodoides)* [186]”. As they ascended higher their bundles of plants increased and “*amid such a great variety it was difficult to make a choice…collected…some of the rare kinds (Dendrobium canaliculatum)* [187] *and a small but handsome orchid with flag leaves (Cryptostylis ovata* [188]*)* ”. As they reached the summit, they “*came upon a complete plantation of Tree Ferns (Alsophila leichhardtii)* [189]. *The striking way in which the leaves branch out in a cluster overhanging the stem all round, like an open parachute, is peculiary beautiful*”. As they were “*completely shut in by the towering pines* [190] *and overshadowing trees of every variety*”, they needed to climb a tree for a view, which “*stretch*[ed] *far away in the distance from the foot of Mount Dryander… lands intersected with running creeks, lined with tall palms (Seaforthia)* [191]”. They proceeded along the summit ridge “*until we reached one of the three prominent peaks which from many points of the compass meet the eye in aspects of Mount Dryander*”. Here they remarked that there were “*rare trees, shrubs, numerous parasitic orchids and ferns, but beneath our feet a perfect carpet of the rarest kinds of moss* [192] *rivalling in freshness of colour and softness the finest Brussels and Turkey manufactures* [193], *and in many places they hung like a thick covering of Berlin wool* [194] *from the rocks on which we walked* ”. At this location they inscribed a tree with their names and the date. At the very summit was “*a high shelving rock surrounded by a mass of ferns and a large number of fig trees (Ficus magnifolia)* [195]”. At about 4.00 pm they began their descent, and eventually reached the top of the first spur to make camp for the night. On the morning of **Thursday 5 July**, they descended to Vine Creek, where they located their horses, and commenced the journey back to Bowen. As there were no further travel details, it is assumed that they returned directly to Bowen.

Results of the Mount Dryander excursions

At least 90 species were collected during the Mount Dryander excursions. Of these, four collections were described as new

Table 7. Type specimens collected by Eugene Fitzalan and/or Frederick Kilner from Mount Dryander. Original species names are retained and the currently used name follows in parentheses. Collections list the location and the specimens relevant to typification, but the status of the typification is not provided as it is beyond the scope of this work. The publication details of the protologue are provided. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Species	**Collection**	**Publication**
Ochrosia kilneri F.Muell. (*Neisosperma kilneri* (F.Muell.) Fosberg & Sachet)	1871, *Fitzalan & Kilner*; MEL 1587728	*Fragm.* 7(56): 129 (1871)
Eulophia fitzalanii F.Muell. ex Benth. (*Eulophia bicallosa* (D.Don) P.F.Hunt & Summerh.)	1871, *Fitzalan*; MEL 0677527	*Fl. Austral.* 6: 300 (1873)
Cleisostoma brevilabre F.Muell. (*Plectorrhiza brevilabris* (F.Muell.) Dockrill	Undated, F*itzalan*; MEL 1540850	*Fragm.* 11(91): 87 (1880)
Solanum sporadotrichum F.Muell.	Undated, *Kilner & Fitzalan*; MEL 0012282	*Australas. Chem. Drugg.* 5: 48 (1882)

species by Mueller (Table 7). The species collected on the expeditions are listed in Table 8. Fitzalan was the primary collector but a few specimens are cited with Kilner as a co-collector and there are a small number where Kilner was recorded as the sole collector. There is no evidence to suggest that Rainbird, Perceval or Rev. J.K. Black had any involvement with plant collecting on any of the Mount Dryander excursions.

Fitzalan was engaged by Ferdinand Mueller as the plant collector on the Dryander excursions. In correspondence to Joseph Hooker (Kew Gardens, England), Mueller wrote [196], in 1869, that "*Mt Dryander has been ascended by Mr Kilner & Mr Fitzalan. Beyond a new Cassia* [197] *no novelties seem to occur, but the Mount gives us some new localities*". In correspondence from Fitzalan to Mueller [198], in 1871, it was noted that "*I enclose you specimens of the New Tree* [199] *from Mount Dryander — I will send by next mail the notes you require on the woods — and some good specimens for the Museum a specimen of this tree amongst them*". This letter was included with one of the sheets associated with the type specimen of *Ochrosia kilneri* F.Muell. (*Neisosperma kilneri* (F.Muell.) Fosberg & Sachet). The first citations concerning the Mount Dryander specimens occurred in December 1870 (Mueller 1870), soon after the first excursion of 1869 (Table 9).

As noted, Rainbird was a collector of land snails on the Mount Dryander excursions. In the account of the excursion of 1869, Perceval noted that "*the naturalist [Rainbird] had least reason to be satisfied with his trip, not having succeeded in finding live specimens of the particular sort which were the especial object of his search. But he found some dead ones, and hopes that he may have better success at a more suitable season*". John Rainbird collected at least 15 specimens of land snails whilst on the Mount Dryander excursions. *Helix rainbirdii* Cox, 1870 [*Bentosites yulei* Forbes, 1851], was described for one of his collections (Cox 1870) and *Helix dryanderensis* Cox, 1872 [*Offachloritis dryanderensis* Cox, 1872] was named for the locality (Cox 1872). Rainbird is cited as the collector of many natural history specimens from Queensland [200].

Mount Elliot Excursions, 1863 and 1872

Table 8. Species collected by Eugene Fitzalan during the Mount Dryander excursions in 1869, and June and July 1872, based on MELISR and AVH herbarium record data. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Abutilon sp.
Acacia longissima H.L.Wendl.
Acacia oswaldii F.Muell.
Alpinia caerulea (R.Br.) Benth.
Antidesma parvifolium Thwaites & F.Muell.
Arthropteris tenella (G.Forst.) J.Sm. ex Hook.f.
Atalaya rigida S.T.Reynolds
Bazzania sp. 'queenslandica'
Blechnum cartilagineum Sw.
Bosistoa pentacocca (F.Muell.) Baill.
Callicarpa pedunculata R.Br.
Calochlaena dubia (R.Br.) M.D.Turner & R.A.White
Capparis canescens Banks ex DC.
Capparis sepiaria L.
Carallia brachiata (Lour.) Merr.
Clausena brevistyla Oliv.
Commersonia bartramia (L.) Merr.
Crotalaria juncea L.
Crotalaria mitchellii Benth. subsp. *mitchellii*
Cryptocarya triplinervis R.Br.
Cyathea rebeccae (F.Muell.) Domin
Denhamia cunninghamii (Hook. M.P.Simmons)
Denhamia disperma (F.Muell. M.P.Simmons)
Desmodium heterocarpon var. *strigosum* van Meeuwen
Dioscorea transversa R.Br.
Diospyros geminata (R.Br.) F.Muell.
Doodia aspera R.Br.
Doryopteris concolor (Langsd. & Fisch.) Kuhn
Endiandra compressa C.T.White
Eulophia bicallosa (D.Don) P.F.Hunt & Summerh.
Euroschinus falcatus Hook.f. var. *falcatus*
Ficus watkinsiana F.M.Bailey
Flindersia schottiana F.Muell.
Ganophyllum falcatum Blume
Glycosmis trifoliata (Blume) Spreng.
Gossia bidwillii (Benth.) N.Snow & Guymer
Grevillea parallela Knight
Grevillea pteridifolia Knight
Heliotropium sarmentosum (Lam.) Craven
Hibbertia scandens (Willd.) Dryand)
Homalanthus populifolius Graham
Hypoestes floribunda R.Br. var. *floribunda*
Lagunaria queenslandica Craven
Larsenaikia jardinei (F.Muell. ex Benth.) Tirveng.
Lastreopsis tenera (R.Br.) Tindale
Mackinlaya macrosciadea (F.Muell.) F.Muell.
Maclura cochinchinensis (Lour.) Corner
Melaleuca sp.
Melastoma malabathricum L. subsp. *malabathricum*
Melodorum leichhardtii (F.Muell.) Benth.
Micromelum minutum (G.Forst.) Wight & Arn.
Monochoria cyanea (F.Muell.) F.Muell.
Niemeyera antiloga (F.Muell.) T.D.Penn.
Neisosperma kilneri (F.Muell.) Fosberg & Sachet
Nephrolepis obliterata (R.Br.) J.Sm.
Niemeyera antiloga (F.Muell.) T.D.Penn.
Nymphoides indica (L.) Kuntze
Parsonsia straminea (R.Br.) F.Muell.
Pavetta australiensis Bremek. var. *australiensis*
Pellaea falcata (R.Br.) Fee
Pimelea latifolia R.Br. subsp. *latifolia*
Piper interruptum Opiz
Pittosporum venulosum F.Muell.
Plectorrhiza brevilabris (F.Muell.) Dockrill
Pleioluma brownlessiana (F.Muell.) Swenson & Munzinger
Pollia macrophylla (R.Br.) Benth.
Pothos longipes Schott
Pyrrhobryum spiniforme (Hedw.) Mitt.
Solanum graniticum A.R.Bean
Solanum sporadotrichum F.Muell.
Swainsona sp.
Syzygium australe (H.L.Wendl. ex Link) B.Hyland
Syzygium claviflorum (Roxb.) Wall. ex Steud.
Tabernaemontana orientalis R.Br.
Tapeinosperma pseudojambosa (F.Muell.) Mez
Terminalia sp.
Trophis scandens (Lour.) Hook. & Arn. subsp. *scandens*
Turraea pubescens Hell.
Vitex melicopea F.Muell.
Vitex trifolia L. var. *trifolia*
Vittaria elongata Sw.

Fitzalan undertook a number of excursions to Mount Elliot. Two of these, in 1863 and 1872, were botanically significant, whilst others such as those performed in 1878 and 1881, were minor diversions made when on route to other locations and with no significant ascent of the mountain.

The excursions to Mount Elliot described here include:

- Mount Elliot with John Dallachy, 2–14 August 1863.
- Mount Elliot Bunya-bunya search excursion, 2– 17 [?] September 1872.

Mount Elliot is situated about 30 km south-east of Townsville and about 45 km north-west of Ayr, and rises to about 1235 m elevation. The derivation of the name Mount Elliot is not known, but it was mentioned by Philip Parker King [as Mount Eliot] in his account of his 1819 voyage (King 1827). Mount Elliot consists of two sections; the eastern sector rising to about 800 m elevation, and separated from the main massif by a low ridge. The eastward facing slopes of the main massif contain notophyll rainforest, whilst the western part has wet sclerophyll forest and Araucarian vine forest. The lower elevation open Eucalypt forests display a close affinity with southern Queensland and the higher altitude rainforest show a distinct affinity to the wet tropics area (Bean 2014).

As with most of Fitzalan's collecting excursions, there is no, or only scant, documentation concerning preparation and logistics, and there are no known reports or records for the 1863 excursion. Of the 1872 excursion there is only a single report that was rerun in various newspapers (Anon. [Fitzalan] 1872). However, the physical record of the herbarium specimens, mainly conserved in BM, BRI, K and MEL, that were collected from Mount Elliot offer a structure in which the excursions can be explained and described.

Mount Elliot excursion with John Dallachy, August 1863

On this excursion, Fitzalan was accompanied by John Dallachy, the experienced plant collector who was also engaged by Ferdinand Mueller. John Dallachy (b.?1805/8, Morayshire, Scotland; d. 4 June 1871, Vale of Herbert, Queensland) was a trained gardener, plantation manager, nurseryman and botanical collector. He collected extensively in Victoria and Queensland, primarily around Rockhampton, Townsville, Seaview Range, Cardwell, and Rockingham Bay. His collections number to ca 6000 specimens, mainly in MEL, but many in BRI, K, PH, among other herbaria (George 2009).

Prior to moving to Queensland in 1862, Dallachy had been living in Victoria and was Superintendent of Melbourne Botanic Gardens [1849–1857] before the position was held by Ferdinand Mueller (Blake 1955; George 2009). Following this he was the herbarium curator for Mueller until 1861. Dallachy collected near Brisbane in late 1862, near Rockhampton in early 1863, and was in Bowen from April–June 1863. Although not documented, it appears that Fitzalan and Dallachy became known to each other and undertook the trip to Mount Elliot as a joint enterprise. Following the excursion, Dallachy became a pioneer settler in Cardwell which remained his main area of residence until his death in 1871 (Blake 1955).

Table 9. Primary citations for specimens collected by Eugene Fitzalan during the excursions to Mount Dryander, arranged in chronological order. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Taxon	**Publication**
Sersalisia sericea (Aiton) R.Br.	*Fragm.* 7(55): 112 (1870)
Amorphospermum antilogum F.Muell. (*Niemeyera antiloga* (F.Muell.) T.D.Penn.)	*Fragm.* 7(55): 113 (1870)
Polypodium tenellum G.Forst. (*Arthropteris tenella* (G.Forst.) J.Sm. ex Hook.f.)	*Fragm.* 7(55): 121 (1870)
Vittaria elongata Sw.	*Fragm.* 7(55): 121 (1870)
Hibbertia volubilis Andrews (*Hibbertia scandens* (Willd.) Dryand.)	*Fragm.* 7(56): 125 (1871)
Ochrosia kilneri F.Muell. (*Neisosperma kilneri* (F.Muell.) Fosberg & Sachet)	*Fragm.* 7(56): 129 (1871)
Cystoseira prolifera J.Agardh (*Hormophysa cuneiformis* (J.F.Gmelin) P.C.Silva	*Fragm.* 7(56): 136 (1871)
Pittosporum venulosum F.Muell.	*Fragm.* 7(57): 140 (1871)
Eulophia sp.	*Fragm.* 8(59): 30 (1873)
Monochoria cyanea(F.Muell.) F.Muell.	*Fragm.* 8(60): 44 (1873)
Pollia cyanococca F.Muell.	*Fragm.* 8(62): 63 (1873)
Eulophia fitzalanii F.Muell. ex Benth. (*Eulophia bicallosa* (D.Don) P.F.Hunt & Summerh.)	*Fl. Austral.* 6: 300 (1873)
Potamogeton tenuicaulis F.Muell. (= *Potamogeton octandrus* Poir.)	*Fragm.* 8(68): 217 (1874)
Cymodocea serrulata (R.Br.) Asch. & Magnus	*Fragm.* 8(68): 218 (1874)
Ptychosperma elegans (R.Br.) Blume	*Fragm.* 8(68): 222 (1874)
Hibiscus elsworthii F.Muell.	*Fragm.* 8(70): 242 (1874)
Flindersia schottiana F.Muell.	*Fragm.* 9(78): 133 (1875)
Pothos loureiri Hook. & Arn. (*Pothos longipes* Schott)	*Fl. Austral.* 7:158 (1878)
Cleisostoma brevilabre F.Muell. (*Plectorrhiza brevilabris* (F.Muell.) Dockrill	*Fragm.* 11(91): 87 (1880)
Solanum sporadotrichum F.Muell.	*Australas. Chem. Drugg.* 5: 48 (1882)

During the whole of 1863, Dallachy collected about 750 specimens, from various localities in Queensland between Rockhampton and Cleveland Bay (AVH 2014; MELISR 2014). Of this number, at least 60 specimens are labelled as collected from Mount Elliot under his name alone. It is not possible to determine the exact number of specimens that Fitzalan collected during the 1863 excursion, as most of his specimens were undated. In total, there are about 230 specimens from all the excursions to Mount Elliot that were collected solely under the name Fitzalan. Other specimens, known to have been collected during the 1863 excursion, were co-collected and labelled as either Fitzalan & Dallachy (at least 10 specimens) or Dallachy & Fitzalan (at least four specimens) (MELISR 2014).

There are no known reports or accounts known for this excursion. The earliest documentation about the venture, to my knowledge, was provided by Mueller in a letter written on 25 September 1863 to William Hooker at Kew Gardens, England, in which Mueller wrote that "*Messrs Fitzalan & Dallachy have just returned from Mount Elliot*" [201]. Specimens from the excursion were first described as new species (Table 10) as early as October 1863 (Mueller 1863a, 1863b), only two months after Fitzalan and Dallachy had completed the excursion. Other new species were described throughout 1864 and then up to 1868, by either Mueller or George Bentham (Table 10). At this time, Bentham was preparing the first volumes of *Flora Australiensis*, and Mueller sent specimens from Melbourne to Kew for this purpose (Daley 1927). Further correspondence from Mueller to August Petermann [202] in August 1864, noted that Mueller had "*received much from north-eastern Australia, and recently Musa australiensis, described as Musa banksi* [203]" which Fitzalan had collected from Mount Elliot during the 1863 expedition. For typification notes on *Musa banksii* see George (2010).

Mount Elliot Bunya-bunya search excursion, September1872

This excursion was intended to locate populations of *Araucaria bidwillii* [204], and to ascertain if "*the fine tree known as the bunya-bunya existed on Mount Elliott*". Some reports "*led botanical writers to suppose that it was a new species of Araucaria, and to desire that specimens should be procured*". Literature references to the mentioned 'botanical writers' have not been located. However, in a report of an excursion to Mount Roundback undertaken by Fitzalan, John Rainbird and Augustus William Simpson [205], in early August of 1872 (Anon.[Fitzalan *et al.*] 1872), it was noted that "*on our way from Townsville we had touched at Mount Elliot, with which a good deal of interest is connected for various reasons, with the intention of ascending it and ascertaining for ourselves the correctness of several questions which hitherto have been only conjecture. We reserve for further notice what we came to the knowledge of, merely stating that the Bunya Bunya tree, the existence of which on Mount Elliot has been disputed, undoubtedly grows there, and its fruit forms one of the chief articles of diet of the natives. Mr. Mark Reid, of Woodstock, who succeeded in procuring some of the fruit from them* [Mount Elliot Aborigines], *was first informed of its whereabouts, which was subsequently reported by Mr. Macmillan to the Acclimatization Society of Brisbane*". *Araucaria bidwillii* is now known to occur in only two disjunct populations, one near Gympie in south-eastern Queensland and the other near Mount Molloy in north-eastern Queensland (Hill 1998), and does not occur on Mount Elliot. Fitzalan collected a specimen of *Araucaria cunninghamii* var. *cunninghamii* from Mount Elliot [206], but it is undated and therefore cannot be assigned to any particular excursion. Fitzalan would have been very familiar with *Araucaria cunninghamii* var. *cunninghamii* as it was the primary timber that he used when constructing the government buildings at Bowen during his building contracts of 1861–1862. It is possible that there may have been confusion as to the identity of the bunya-bunya from sources other than Fitzalan, and the Mount Elliot reports possibly referred correctly to *Araucaria cunninghamii* var. *cunninghamii*. To facilitate identification of the pine, Fitzalan took with him "*a good-sized branch of the real bunya-bunya (Araucaria Bidwellii)*". It is not explained how Fitzalan acquired this, but it is possible that plants at that time were cultivated in Bowen.

On **Tuesday 2 September 1872**, Fitzalan in the company of his "*frequent companion, Mr. Rainbird*" departed Bowen and proceeded on the road northward toward Mount Elliot [see Mount Dryander excursion above for biographical details about John Rainbird). After travelling for about three days, they stopped at Woodstock Station, a pastoral property then owned by John Melton Black and Robert Towns (Pike 1996; Carver 1993) (Figure 12). Woodstock Station was one of the first pastoral runs established in the Mount Elliot area [ca 1862] and pre-dates the formation of the Ross River port in 1864 which was to become Townsville in 1865 (Pike 1996). The original Woodstock Station was to the south-east of Mount Elliot near the junction of Majors Creek and Haughton River (Jack 1878), and not to be confused with the present township of Woodstock which is about 30 km to the north-west of this location (Figure 12). From Woodstock Station "*and after a couple of days' scrub-hunting on the Haughton, where my companion found a new Helix* [207], *we started for the mountain, some 12 miles* [19.3 km] *distant*". Haughton River, which has its source in the Mingela Range to the south-west of Mount Elliot enters Bowling Green Bay to the east of Mount Elliot. Fitzalan's reference could relate to the middle reaches of the river as that area is about 12 miles [19.3 km] on average from Mount Elliot.

On about **6 September,** they ascended the mountain, presumably from the east or south-east, and "*kept up the search for seven days, following the creeks and gorges to their sources, and ascending the mountain at various points*". Fitzalan observed that "*there are no tropical scrubs* [208]*on Mount Elliott such as botanists delight in…on top you find yourself in open grassy forest* [209], *timbered with messmate* [210], *stringy barks* [211], *and forest oak* [212]". After realising that the search for the bunya-bunya was not going to be successful, they "*came to the conclusion that the black fellows were right and that it* [*Araucaria bidwillii*] *did not sit down*" on the mountain. 'Sit down' was a corrupted-English term used by the Aborigines to describe something being present at a place, i.e., the pine did not 'sit down' on Mount Elliot. In spite of this, Fitzalan "*got many specimens of interest, and amongst others some seed and specimens of a very handsome new palm* [213] *of dwarf habit and rapid growth*" and that "*Mr. R. also found some new land shells* [214]". The assumption that they approached the mountain from the east is supported by the fact that the *Araucaria cunninghamii* var. *cunninghamii* the species which *Araucaria bidwillii* may have been confused with, only occurs on the western ridges and slopes (Figure 12). In addition, Fitzalan noted that "*there are some fine dense palm scrubs* [215] *on some of the running creeks on the eastern side of the mountain*". Furthermore, if they had approached the mountain from the west or north-west, the populations of *Araucaria* would have been seen, as they are very conspicuous in that area. The populations are otherwise not able to be seen from the east or south. Considering the timing mentioned in the report, they would have returned to Bowen about **17 September**.

Results of the Mount Elliot excursions

Fitzalan collected about 240 specimens from all the excursions he took to Mount Elliot. There are a further 60 specimens that were collected by John Dallachy during the 1863 excursion, and about 15 specimens are recorded as being co-collected by them. In total, this amounts to about 315 species collected during the excursions.

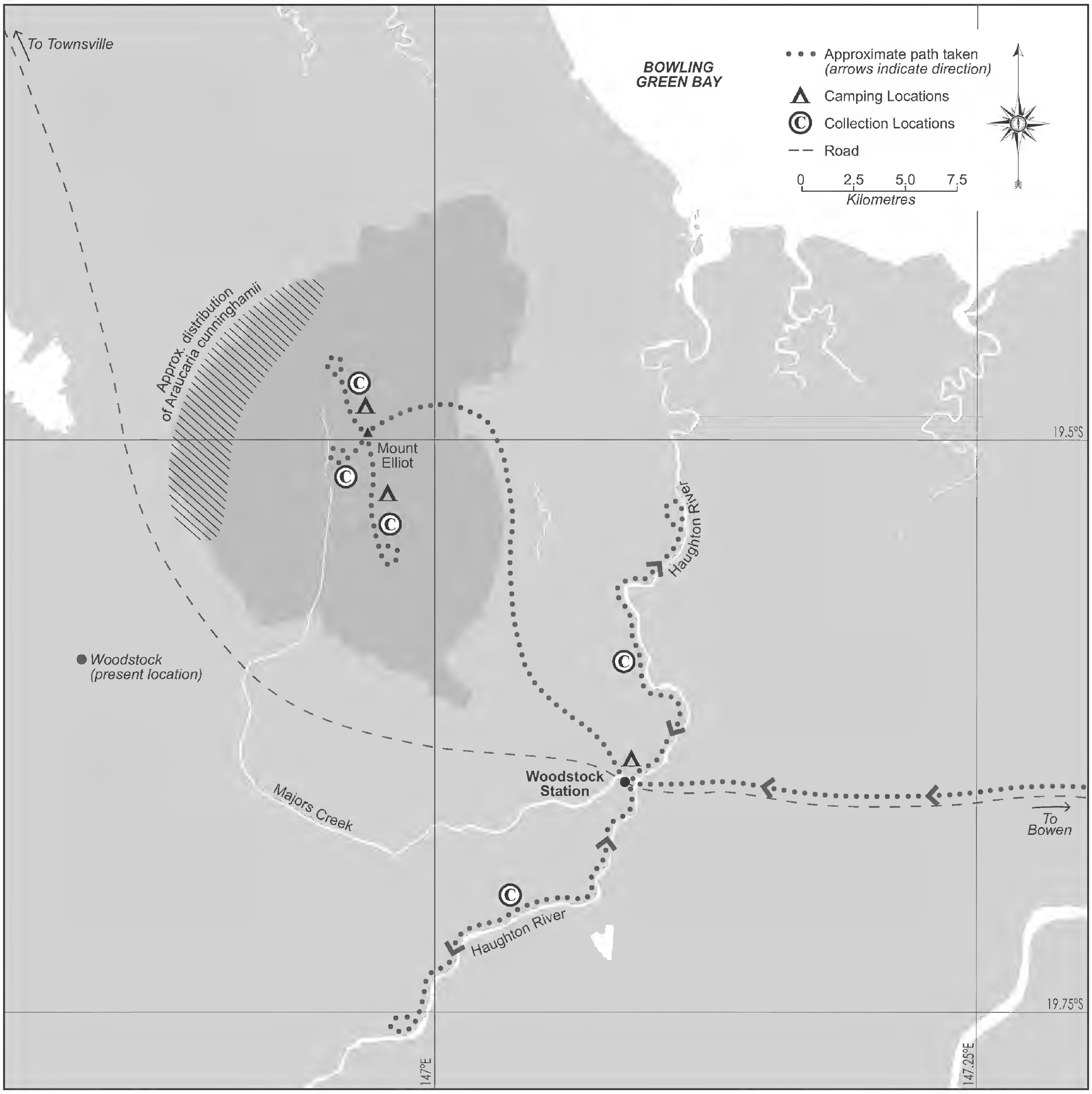


Fig. 12. Map of the approximate paths taken during the excursion to Mount Elliot, 2–17 September 1872. Prepared by Claire Burton, Cairns Regional Council.

Fourteen type specimens were collected (Table 10), representing mainly understory shrubs and trees. None of these taxa are endemic to Mount Elliot, but overall indicate a close association with taxa from areas to the north. An examination of the relevant literature produced about 38 citations for specimens collected from Mount Elliot by Fitzalan and Fitzalan & Dallachy (Table 11). The first citations were provided by Mueller within months of them returning from the 1863 excursion - an indication of the characteristic efficiency that Mueller applied to his plant taxonomy. A list of all species, from all the Mount Elliot excursions, is presented in Table 12.

Whitsunday Island Excursion, June 1874

The Whitsunday Island excursion of June 1874, was described in an informal newspaper report that appeared in the *Port Denison Times* [216]. The participants were only identified by characterised monikers: Fitzalan was named as '*Palmseed*' and John Rainbird as '*Muttonfish*'. The true identities of the other four party members are not known.

The excursion was made during **June 1874**, but exact dates were not recorded. The excursion departed Bowen at 4.00 pm, and the first night camp was made at Gloucester Passage (Figure 13). The excursion passed between Saddleback Island and George Point during the following morning, and the second night camp was made on Gumbrel [Gumbrell] Island. The next morning on Gumbrell Island, "*the party amused themselves by fossicking in the scrub for land shells and plants, and found growing in wild profusion the scented sage (Salvia)* [217] *and the same sort of convolvulus that grows on the beach at Port Denison, but having a pure white flower* [218]". The party sailed onto Double Cone Island where "*all hands went to the reef, which is exposed at the lowest tides, seeking shells, reptilia &c., which are obtained by following the water as it recedes*". Continuing on, they passed round Pioneer Point and entered Port Molle, where they camped for the third night on Little Pine Island [Shute Island] for the night. The following morning they landed on Long Island to obtain water from '*Flinders' Well*'. The fourth night camp was made on Henning Island, where "*all hands went fossicking for what they could find in the scrub with which this island is almost covered* [219]. *Palmseed found a great quantity of his namesakes* [220], *and all got plenty of the beans thought so much of for matchboxes* [221]".

Whitsunday Island was reached late in the afternoon, and the fifth night camp was made. The following day the area around Fitzalan's Point was explored, where there was "*a blue bean* [222] *of the same size and shape as the common red variety* [223]

Table 10. Type specimens collected by Eugene Fitzalan or co-collected with John Dallachy during the Mount Elliot excursions, 1863–1881. Original species names are retained and the currently used name follows in parentheses. Collections list the location and the specimens relevant to typification, but the status of the typification is not provided as it is beyond the scope of this work. The publication details of the protologue are provided. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Taxon	Collection	Publication
Ardisia pseudojambosa F.Muell. (*Tapeinosperma pseudojambosa* (F.Muell) Mez	1863, *Fitzalan 6*; MEL1612768, MEL1612770	*Fragm*. 4(26): 81 (1864)
Argophyllum lejourdanii F.Muell.	1863, *Fitzalan & Dallachy*; K000739401, MEL0568353, MEL0568354	*Fragm*. 4(25): 33 (1863)
Chionanthus effusiflorus F.Muell.[Australian Plant Census excluded name]	1863, *Dallachy & Fitzalan*; No known specimens	*Fragm*. 4(26): 83 (1864)
Cordyline manners-suttoniae F.Muell.	*Fitzalan*; K000644213, MEL645614;	*Fragm*. 5(40): 195 (1866)
Eucalyptus hemiphloia var. *parviflora* Benth. (*Eucalyptus crebra* F.Muell.)	*Fitzalan*: No known specimens	*Fl. Austral*. 3: 217 (1867)
Ficus magnifolia F.Muell. (*Ficus copiosa* Steud.)	1863, *Fitzalan & Dallachy*; MEL1063140, MEL1063142	*Fragm*. 4(25): 50 (1863)
Macaranga mallotoides F.Muell. (*Macaranga involucrata* (Wall.) Baill. Ex Mull.Arg.)	*Fitzalan*; MEL0708347	*Fragm*. 4(29): 139 (1864)
Mallotus pycnostachys F.Muell. (*Mallotus mollissimus* (Geiseler) Airy Shaw)	*Fitzalan*; MEL0232432, MEL0232433, MEL0232434	*Fragm*. 4(29): 138 (1864)
Musa banksia F.Muell.	1863, *Fitzalan*; MEL0621535; BRIAQ0023362, EBC29543	*Fragm*. 4(28): 132 (1864)
Psoralea cephalantha F.Muell. (*Lotodes cephalantha* (F.Muell.) Kuntze)	1863, *Fitzalan & Dallachy*; K000217483, MEl1563596; MEL1563594, MEL1563595, MEL1563597	*Fragm*. 4(25): 35 (1863)
Ptychosperma beatricae F.Muell. (*Archontophoenix alexandrae* (F.Muell.) H.Wendl. & Drude)	1881 & 1882, *Fitzalan*; BRIAQ0342251, FI029, MEL0516567, MEL0516568, MEL0516569, MEL0516570, MEL0516578, MEL0516579, MEL0516581 – 83	*Australas. Chem. Drugg*. 4(46): 77 (1882)
Rhynchosia cunninghamii Benth. (*Rhynchosia acuminatissima* Miq.)	*Fitzalan*; K000279359, K000279361, MEL2046612	*Fl. Austal*. 2: 266 (1864)
Strychnos psilosperma F.Muell. (*Strychnos axillaris* Colebr.)	1863, *Fitzalan & Dallachy* ; K, MEL707285, MEL707282, MEL707283	*Fragm*. 4(25): 44 (1863)
Vincetoxicum leptolepis Benth. (*Cynanchum leptolepis* (Benth.) Domin)	*Fitzalan 83*; BRIAQ0333129, MEL0113313	*Fl. Austral*. 4: 331 (1868)

but it was not the season”. The sixth night camp was made on Whitsunday Island. The next morning they commenced the journey back to Bowen, landing on Double Cone Island where they camped for the seventh night. As the tides were favourable for shelling, another day and night were spent on the island. Fitzalan and Rainbird ‘*went off together to make a day of it in their own particular line…every one was very fortunate and collected some nice specimens*”. After the ninth night camp was made in the Gloucester Passage, Bowen was reached in the evening of the next day.

Results of the Whitsunday Island Excursion

There appears to have been no new species collected or significant new distribution records made during this excursion. A list of plant species, collected during 1874 but otherwise lacking exact location data, is presented in Table 13.

Daintree River Excursions, 1875 and 1876

The Daintree River was first explored in December 1873 by George Elphinstone Dalrymple during the North-east Coast Expedition and Dalrymple named it for Richard Daintree (1832–1878), geologist, Agent-General for Queensland [1872–1876], photographer and plant collector (Dalrymple 1874). It was noted by Walter Hill (1874), the Queensland Government Botanist who accompanied Dalrymple on the North-east Coast Expedition, that the Daintree River was “*bordered with dense vegetation extending for miles back from their banks* [224]” and that “*timber suitable for building purposes is almost everywhere to be obtained* [225]” . Hill’s collections of 1873 represented the first botanising to occur on the Daintree River (Mueller 1874b, 1875). During 1874, and in response to Dalrymple’s and Hill’s encouraging descriptions, southern companies sent timber-getters to the river to look for stands of millable timber (Franken 2008), and by late 1874 the area was being coined as ‘The Cedar

Table 11. Primary citations for specimens collected by Eugene Fitzalan during the excursions to Mount Elliot, arranged in chronological order. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Taxon	Citation
Triumfetta pilosa Roth	*Fragm.* 4(25): 28 (1863)
Rubus rosifolius Sm.	*Fragm.* 4(25): 32 (1863)
Argophyllum lejourdanii F.Muell.	*Fragm.* 4(25): 33 (1863)
Psoralea cephalantha F.Muell. (*Lotodes cephalantha* (F.Muell.) Kuntze)	*Fragm.* 4(25): 35 (1863)
Strychnos psilosperma F.Muell. (*Strychnos axillaris* Colebr.)	*Fragm.* 4(25): 44 (1863)
Pimelea latifolia R.Br.	*Fragm.* 4(25): 49 (1863)
Ficus magnifolia F.Muell. (*Ficus copiosa* Steud.)	*Fragm.* 4(25): 50 (1863)
Ardisia pseudojambosa F.Muell. (*Tapeinosperma pseudojambosa* (F.Muell) Mez	*Fragm.* 4(26): 81 (1864)
Chionanthus effusiflorus F.Muell.[APC excluded name]	*Fragm.* 4(26): 83 (1864)
Epicarpurus orientalis Blume	*Fragm.* 4(26): 89 (1864)
Musa banksii F.Muell.	*Fragm.* 4(28): 132 (1864)
Mallotus pycnostachys F.Muell. (*Mallotus mollissimus* (Geiseler) Airy Shaw)	*Fragm.* 4(29): 138 (1864)
Macaranga mallotoides F.Muell. (*Macaranga involucrata* (Wall.) Baill. Ex Mull.Arg.)	*Fragm.* 4(29): 139 (1864)
Nephelia (Cupania) semiglauca (*Guioa semiglauca* (F.Muell.) Radlk.)	*Fragm.* 4(30): 158 (1864)
Rhynchosia cunninghamii Benth. (*Rhynchosia acuminatissima* Miq.)	*Fl. Austal.* 2: 266 (1864)
Ixora klanderiana F.Muell. (*Ixora timorensis* Decne.)	*Fragm.* 5(31): 18 (1865)
Freycinetia excelsa F.Muell.	*Fragm.* 5(32): 40 (1865)
Aglaia elaeagnoidea (A.Juss.) Benth.	*Fragm.* 5(37): 145 (1866)
Cordyline manners-suttoniae F.Muell.	*Fragm.* 5(40): 195 (1866)
Piper novae-hollandiae Miq. (*Piper hederaceum* (Miq.) C.CD. var. *hederaceum*)	*Fragm.* 5(40): 198 (1866)
Vitis oblonga Benth. (*Cissus oblonga* (Benth.) Planch.)	*Fragm.* 5(40): 210 (1866)
Melaleuca genistifolia Sm. (*Melaleuca decora* (Salisb.) Domin)	*Fl. Austral.* 3: 144 (1866)
Eucalyptus hemiphloia var. *parviflora* Benth. (*Eucalyptus crebra* F.Muell.) – Fitzalan’s Ironbark	*Fl. Austral.* 3: 217 (1867)
Vincetoxicum leptolepis Benth. (*Cynanchum leptolepis* (Benth.) Domin)	*Fl. Austral.* 4: 331 (1868)
Sloanea langii F.Muell.	*Fragm.* 8(58): 3 (1872)
Pollia cyanococca F.Muell.	*Fragm.* 8(62): 63 (1873)
Geophila reniformis (D.Don (*Geophila repens* (L.) I.M.Johnst.)	*Fragm.* 8(65): 147 (1873)
Myriophyllum verrucosum Lindl.	*Fragm.* 8(66): 163 (1874)
Ceratophyllum demersum L.	*Fragm.* 8(66): 163 (1874)
Notholaena vellea R.Br. (*Cheilanthes brownii* (Kuhn) Domin)	*Fragm.* 8(66): 176 (1874)
Colocasia antiquorum Schott (*Colocasia esculenta* (L.) Schott	*Fragm.* 8(67): 187 (1874)
Xerotes longifolia (Labill.) R.Br. (*Lomandra longifolia* Labill.)	*Fragm.* 8(68): 210 (1874)
Abutilon micropetalum Benth.	*Fragm.* 9(78): 131 (1875)
Cedrela toona Roxb. Ex Rottler (*Toona ciliata* M.Roem.)	*Fragm.* 9(78): 133 (1875)
Owenia acidula F.Muell.	*Fragm.* 9(78): 134 (1875)
Cephaelis reniformis Kunth (*Geophila reniformis* (L.) I.M.Johnst.)	*Fragm.* 9(80): 187 (1875)
Nelumbo nucifera Gaertn.	*Fragm.*10(85): 77 (1876)
Lygodium scandens (L.) Sw. (*Lygodium flexuosum* (L.) Sw.)	*Fragm.*10(87): 118 (1877)
Hibiscus splendens C.Fraser ex Graham	*Fragm.* 11(89): 31 (1878)
Polypodium rigidulum Sw. (*Drynaria rigidula* (Sw.) Bedd.)	*Fl. Austral.* 7:771 (1878)
Hibbertia volubilis Andrews (*Hibbertia scandens* (Willd.) Dryand.)	*Fragm.* 11(92): 94 (1880)
Plagiochila pendula Hampe & Gottsche (*Plagiochila metcalfii* Steph.)	*Fragm.* 11 (Suppl.): 55 (1880)
Ptychosperma beatricae F.Muell. (*Archontophoenix alexandrae* (F.Muell.) H.Wendl. & Drude)	*Australas. Chem. Drugg.* 4(46): 77 (1882)

Country' because of the abundance of valuable timbers [226]. At the high rates of extraction, the accessible timber was rapidly depleted and large areas of forest were decimated [227]. By the 1880s, most of the timber camps were abandoned and only a few settlers remained (Pike 1996).

It is against this background that Fitzalan visited the Daintree River in 1875 and again in 1876. It is not known under what circumstances Fitzalan visited the area and he was not mentioned as a member of any of the exploration parties that were active during this time. There are no known detailed published records or accounts of either of Fitzalan's excursions to the Daintree River. The exact dates of the Daintree River excursions are not known, although shipping notifications indicate that Fitzalan visited Sydney in 1875, arriving there on the *S.S. Leichhardt* on 3 June. The details about his return journey have not been located. He appears to have visited Cooktown and the Daintree River area during July/August 1875 and it was noted that "*Mr Fitzalan, well known to residents in the north as a botanist, has been in this neighbourhood for several weeks past, collecting plants. He informs us he has been successful beyond expectation in obtaining some plants new to botany, and in getting a large number of fine specimens of species, already known. A portion of the plants collected are for shipment to England, but the majority go to Baron von Mueller*" [228]. Some of the new plants were noted in forthcoming reports: "*As the genus Leichhardtia of the Asclepiads was subsequently reduced to Marsdenia, he* [Mueller] *now proposes to transfer the honoured name of Leichhardt to a new genus of the Menispermeae, founded on a plant recently discovered by Mr. E. Fitzalan, near Daintree River*" [229]. This revised taxonomy was published by Mueller (1876), before July 1876, suggesting that it was a collection

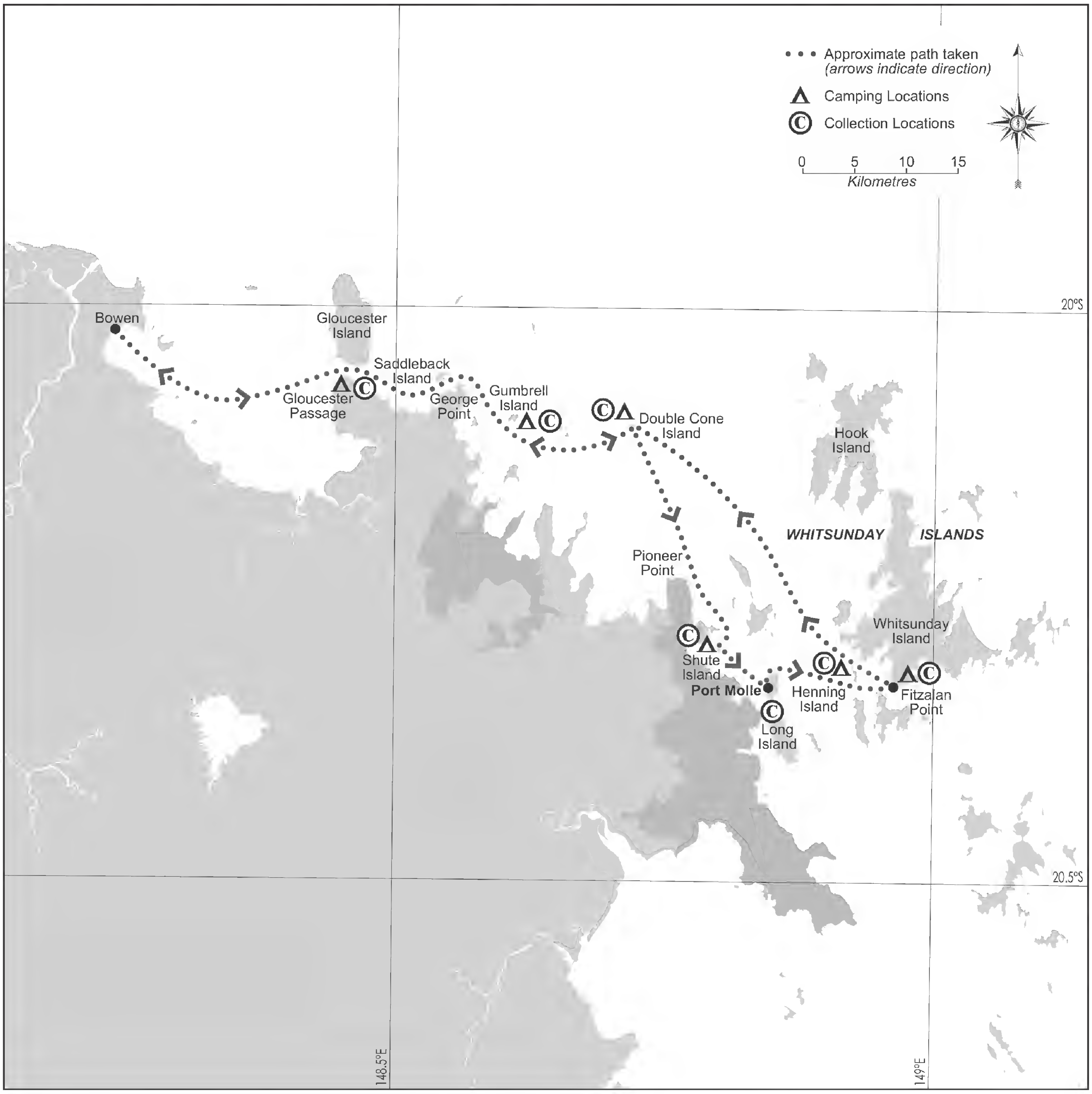


Fig. 13. Map of the approximate paths taken during the excursion to Whitsunday Island, June 1874. Prepared by Claire Burton, Cairns Regional Council.

Table 12. Species collected by Eugene Fitzalan during the Mount Elliot excursions. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Abroma fastuosa R.Br.
Acacia maidenii F.Muell.
Adiantum aethiopicum L.
Adiantum hispidulum Sw.
Aglaia elaeagnoidea (A.Juss.) Benth.
Ajuga australis R.Br.
Albizia canescens Benth.
Alocasia brisbanensis (F.M.Bailey) Domin
Alyxia spicata R.Br.
Ampelopteris prolifera (Retz.) Copel.
Antidesma parvifolium Thwaites & F.Muell.
Apocynaceae
Araucaria cunninghamii Aiton ex A.Cunn. var. *cunninghamii*
Archidendron grandiflorum (Sol. ex Benth.) I.C.Nielsen
Archontophoenix alexandrae (F.Muell.) H.Wendl. & Drude
Argophyllum lejourdanii F.Muell.
Atalaya hemiglauca (F.Muell.) F.Muell. ex Benth.
Atalaya rigida S.T.Reynolds
Atractocarpus fitzalanii (F.Muell.) Puttock subsp. *fitzalanii*
Baloghia inophylla (G.Forst.) P.S.Green
Blechnum cartilagineum Sw.
Brachychiton acerifolius (A.Cunn. ex G.Don) Macarthur & C.Moore
Breynia cernua (Poir.) Mull.Arg.
Bryidae
Bursaria incana Lindl.
Callicarpa pedunculata R.Br.
Calochlaena dubia (R.Br.) M.D.Turner & R.A.White
Calophyllum inophyllum L.
Capparis mitchellii Lindl.
Carallia brachiata (Lour.) Merr.
Cassia brewsteri (F.Muell.) Benth.
Castanospermum australe A.Cunn. & C.Fraser ex Hook.
Ceratophyllum demersum L.
Cheilanthes brownii (Kuhn) Domin
Cheilolejeunea imbricata (Nees) S.Hatt.
Cissus cardiophylla (F.Muell.) Jackes
Cissus oblonga (Benth.) Planch.
Clerodendrum floribundum var. *angustifolium* Moldenke
Clerodendrum longiflorum var. *glabrum* Munir
Cordyline cannifolia R.Br.
Cordyline manners-suttoniae F.Muell.
Corymbia setosa (Schauer) K.D.Hill & L.A.S.Johnson
Coveniella poecilophlebia (Hook.) Tindale
Crotalaria mitchellii Benth. subsp. *mitchellii*
Crotalaria retusa L.
Cryptocarya triplinervis R.Br. var. *triplinervis*
Cullen badocanum (Blanco) Verdc.
Cupaniopsis wadsworthii (F.Muell.) Radlk.
Cycas media R.Br. subsp. *media*
Cyclosorus interruptus (Willd.) H.Ito
Cynanchum leptolepis (Benth.) Domin
Cyperus lucidus R.Br.
Dendrophthoe glabrescens (Blakely) Barlow
Denhamia cunninghamii (Hook.) M.P.Simmons
Dioscorea bulbifera L.
Dolichandrone heterophylla (R.Br.) F.Muell.
Doodia aspera R.Br.
Dysoxylum gaudichaudianum (A.Juss.) Miq.
Ehretia acuminata R.Br. var. *acuminata*
Elattostachys bidwillii (Benth.) Radlk.
Endiandra compressa C.T.White
Entada rheedii Spreng.
Eucalyptus crebra F.Muell.
Eucalyptus melanophloia F.Muell.
Eucalyptus moluccana Roxb.
Eucalyptus persistens L.A.S.Johnson & K.D. Hill
Eucalyptus platyphylla F.Muell.
Eucalyptus tereticornis Sm.
Eucalyptus xanthoclada Brooker & A.R.Bean
Eugenia reinwardtiana (Blume) DC.
Ficus adenosperma Miq.
Ficus copiosa Steud.
Ficus opposita Miq.
Ficus rubiginosa Desf. ex Vent. f. *rubiginosa*
Freycinetia excelsa F.Muell.
Ganophyllum falcatum Blume
Geophila repens (L.) I.M.Johnst.
Goodenia grandiflora Sims.
Gossia bidwillii (Benth.) N.Snow & Guymer
Grevillea parallela Knight
Grevillea pteridifolia Knight
Grevillea striata R.Br.
Guioa acutifolia Radlk.
Hakea arborescens R.Br.
Heritiera littoralis Dryand.
Hibiscus splendens C.Fraser ex Graham
Homalanthus populifolius Graham
Hovea longipes Benth.
Hydrilla verticillata (L.f.) Royle
Hypoestes floribunda R.Br. var. *floribunda*
Ixora timorensis Decne.
Jasminum didymum subsp. *racemosum* (F.Muell.) P.S.Green
Kennedia rubicunda (Schneev.) Vent.
Larsenaikia jardinei (F.Muell. ex Benth.) Tirveng.
Lastreopsis tenera (R.Br.) Tindale
Limnophila sp.
Limnophila brownii Wannan
Lomandra hystrix (R.Br.) L.R.Fraser & Vickery
Lophostemon grandiflorus subsp. *riparius* (Domin) Peter G.Wilson & J.T.Waterh.
Lopidium struthiopteris (Brid.) M.Fleisch.
Lotodes cephalantha (F.Muell.) Kuntze
Lygodium flexuosum (L.) Sw.
Macaranga involucrata (Wall.) Baill. ex Mull.Arg.
Mallotus mollissimus (Geiseler) Airy Shaw
Mallotus philippensis (Lam.) Mull.Arg.
Mallotus polyadenos F.Muell.
Melaleuca bracteata F.Muell.
Melastoma malabathricum L. subsp. *malabathricum*
Melia azedarach L.
Melodorum leichhardtii (F.Muell.) Benth.
Musa banksii F.Muell.
Myriophyllum verrucosum Lindl.
Myristica globosa subsp. *muelleri* (Warb.) W.J.de Wilde
Myristica insipida R.Br.
Myrsine porosa F.Muell.
Neisosperma poweri (F.M.Bailey) Fosberg & Sachet
Nelumbo nucifera Gaertn.
Neolitsea brassii C.K.Allen
Niemeyera antiloga (F.Muell.) T.D.Penn.
Ottelia ovalifolia (R.Br.) Rich. subsp. *ovalifolia*
Owenia acidula F.Muell.
Pachygone ovata (Poir.) Hook.f. & Thomson
Pararchidendron pruinosum (Benth.) I.C.Nielsen var. *pruinosum*
Pavetta australiensis Bremek. var. *australiensis*
Persoonia falcata R.Br.
Philydrum lanuginosum Banks & Sol. ex Gaertn.
Pimelea latifolia R.Br. subsp. *latifolia*
Pisonia aculeata L.
Pisonia umbellifera (J.R.Forst. & G.Forst.) Seem.
Pittosporum revolutum Dryand.
Pittosporum venulosum F.Muell.
Platysace valida (F.Muell.) F.Muell.
Pleiogynium timorense (DC.) Leenh.
Potamogeton octandrus Poir.
Proiphys amboinensis (L.) Herb.
Pseudocyphellaria diplomorpha (Mull.Arg.) D.J.Galloway

Psilotum nudum (L.) P.Beauv.
Psydrax odorata f. *australiana* S.T.Reynolds & R.J.F.Hend.
Pteridium esculentum x *Pteridium revolutum*
Pteridium revolutum (Blume) Nakai
Pteris tremula R.Br.
Ptilotus helipteroides (F.Muell.) F.Muell.
Pyrrhobryum spiniforme (Hedw.) Mitt.
Pyrrosia rupestris (R.Br.) Ching
Racopilum cuspidigerum var. *convolutaceum* (Mull.Hal.) Zanten & Dijkstra
Rhynchosia acuminatissima Miq.
Rubus moluccanus L var. *moluccanus*
Rubus probus L.H.Bailey
Senna gaudichaudii (Hook. & Arn.) H.S.Irwin & Barneby
Sloanea langii F.Muell.
Solanum erianthum D.Don
Stephania japonica var. *timoriensis* (DC.) Forman
Strychnos axillaris Colebr.
Syzygium australe (H.L.Wendl. ex Link) B.Hyland
Tabernaemontana pandacaqui Lam.
Tapeinosperma pseudojambosa (F.Muell.) Mez
Terminalia sericocarpa F.Muell.
Teucrium argutum R.Br. var. *argutum*
Toona ciliata M.Roem.
Triumfetta pilosa Roth
Turraea pubescens Hell.
Utricularia australis R.Br.
Vitex melicopea F.Muell.
Vitex trifolia var. *subtrisecta* (Kuntze) Moldenke
Vittaria elongata Sw.
Ximenia americana L.

made by Fitzalan in 1875. *Leichhardtia*, sensu Mueller, was later placed as a section under *Phyllanthus* L. (Diels 1931) in the Phyllanthaceae.

Results of the Daintree excursions

Mueller had engaged Fitzalan to collect for him in the Daintree area and about 200 specimens were subsequently gathered during the excursions (AVH 2014; MELISR 2014). Of these, ten specimens represented type materials (Table 14). The first citations related to Fitzalan's Daintree collections appeared in November 1875 (Table 15). In correspondence to Edward Ramsay in January 1876 [230], Mueller commented on Fitzalan's 1875 collections: "*Mr Fitzalan's last collections disappointed me; he lost his time about terrestrial & other common ferns, and missed meanwhile the trees which likely would have contained a fair percentage of novelty. We know now however through him two more Musas* [231] *sufficiently accurately for naming*" . This apparent remiss on Fitzalan's behalf is evident in the specimens; of the species collected by him in the Daintree in the 1875 excursion, 56 of the 160 species (35%) collected were Pteridophytes. Nevertheless, three fern collections from that excursion were described as new species (Table 14). There is no explanation why Fitzalan concentrated on the Pteridophytes during the 1875 excursions, and correspondingly there were no Pteridophytes collected during the 1876 excursion during which a total of about 40 plant species were collected (Table 16).

Table 13. Species possibly collected by Eugene Fitzalan during the Whitsunday Island Excursion, June 1874. Taxonomy follows that presented in Australian Plant Census (2014), Australian Plant Name Index (2014) and Bryophytes (2014).

Acacia decora Rchb.
Acacia leptostachya Benth.
Adiantum hispidulum Sw.
Allocasuarina torulosa (Aiton) L.A.S.Johnson
Ampelopteris prolifera (Retz.) Copel.
Blechnum cartilagineum Sw.
Bosistoa pentacocca (F.Muell.) Baill.
Buchnera tetragona R.Br.
Cajanus reticulatus (Aiton) F.Muell.
Capparis sepiaria L.
Cassia brewsteri (F.Muell.) Benth.
Ceratophyllum demersum L.
Cheilanthes tenuifolia (Burm.f.) Sw.
Clerodendrum inerme (L.) Gaertn.
Colocasia esculenta (L.) Schott
Cordyline murchisoniae F.Muell.
Coronidium lanuginosum (A.Cunn. ex DC.) Paul G.Wilson
Coveniella poecilophlebia (Hook.) Tindale
Crotalaria medicaginea Lam.
*Croton acronychioides*F.Muell.
Cullen leucanthum (F.Muell.) J.W.Grimes
Cyathea rebeccae (F.Muell.) Domin
Cycas media R.Br.
Deeringia amaranthoides (Lam.) Merr.
Dioscorea transversa R.Br.
Doodia caudate (Cav.) R.Br.
Doryopteris concolor (Langsd. & Fisch.) Kuhk
Drosera indica L.
Drynaria rigidula (SW.) Bedd.
Ehretia acuminate R.Br.
Elaeagnus triflora Roxb.
Entada rheedii Spreng.
Eremophila mitchellii Benth
Goniophlebium percussum (Cav.) W.H.Wagner & Grether
Grevillea parallela Knight
Hanslia ormocarpoides (DC.) H.Ohashi
Heliotropium sarmentosum (Lam.) Craven
Jasminum simplicifolium G.Forst.
Lagunaria queenslandica Craven
Lastreopsis tenera (R.Br.) Tindale
Miliusa brahei (F.Muell.) Jessup
Murdannia gigantea (Vahl) G.Bruckn.
Ochrosia elliptica Labill.
Parsonsia plaesiophylla S.T.Blake
Pipturus argenteus (G.Forst.) Wedd.
Platostoma longicorne (F.Muell.) A.J.Paton
Pollia macrophylla (R.Br.) Benth.
Proiphys amboinensis (L.) Herb.
Psydrax saligna S.T.Reynolds & R.J.F.Henderson
Pteris ensiformis Burm.f.
Pteris tremula R.Br.
Ptilotus nobilis (Lindl.) F.Muell.
Pyrrosia rupestris (R.Br.) Ching
Scaevola spinescens R.Br.
Senna surattensis (Burm.f) H.S.Irwin & Barneby
Solanum dianthophorum Dunal
Sterculia quadrifida R.Br.
Stylidium velleioides A.R.Bean
Thuidium cymbifolium (Dozy & Molk.) Dozy & Molk.
Thysanotus banksia R.Br.
Trema orientalis (L.) Blume
Velleia spathulata R.Br.
Xerochrysum bracteatum (Vent.) Tzvelev
Xyris complanata

Table 14. Type specimens collected by Eugene Fitzalan on the Daintree River excursions, 1874–1875. Original species names are retained and the currently used name follows in parentheses. Collections list the location and the specimens relevant to typification, but the status of the typification is not provided as it is beyond the scope of this work. The publication details of the protologue are provided. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Taxon	Collection	Publication
Adiantum hispidulum var. *fitzalani* Bail. (*Adiantum diaphanum* Blume)	1874?, *Fitzalan*; BR5631407, BRIAQ0142440, MEL0692079	*Compr. Cat. Queensland Pl.* 641 (1913)
Albizia ramiflora F.Muell. (*Archidendron ramiflorum* (F.Muell.) Kosterm.	1875, *Fitzalan*; BRIAQ022811, MEL0079719, MEL0079772, MEL0079742	*Fragm.* 9(80): 178 (1875)
Elaeocarpus grahamii F.Muell.	1875, *Fitzalan*; BRIAQ0185003, BRIAQ0335730, MEL2226073, MEL2226074, MEL2226076, MEL2226077	*Fragm.* 10(81): 3 (1876)
Grammitis ampla F.Muell. ex Benth. (*Colysis ampla* (F.Muell. ex Benth.) Copel.)	1875, Fitzalan; P00626878	*Fl. Austral.* 7: 777 (1878)
Leichhardtia clamboides F.Muell. (*Phyllanthus clamboides* (F.Muell.) Diels)	*Fitzalan*; K001056764; NSW247354	*Fragm.* 10(84): 68 (1876)
Musa banksii var. *muelleriana* Domin (*Musa banksii* F.Muell.)	1875, *Fitzalan*; BRIAQ0067959, MEL0621528, MEL0621529	*Biblioth. Bot.* 20(85): 536 (1915)
Musa fitzalanii F.Muell.	1875, *Fitzalan*; BRIAQ0023360, MEL0657777, MEL0657778, MEL0657779, MEL0657780, MEL0657781, MEL0657782	*Fragm.* 9(80): 188 (1875)
Musa hillii F.Muell. (*Musa jackeyi* W.Hill)		*Fragm.*9(79): 169 (1875)
Selaginella australiensis Baker	1875 & 1882, *Fitzalan*; BRIAQ0174209, MEL2063105	*J. Bot.* 21: 144 (1883)
Tetracera wuthiana F.Muell. (*Tetracera nordtiana* var. *wuthiana* (F.Muell.) Hoogland	1876, Fitzalan; MEL2227163, MEL2283236	*Fragm.* 10(83): 49 (1876)

Table 15. Primary citations for specimens collected by Eugene Fitzalan during the excursions to the Daintree River, arranged in chronological order. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Taxon	Citation
Orthosiphon stamineus Benth. (*Orthosiphon aristatus* (Blume) Miq.)	*Fragm.* 9(79): 161 (1875)
Musa hillii F.Muell. (*Musa jackeyi* W.Hill)	*Fragm.* 9(79): 169 (1875)
Albizia ramiflora F.Muell. (*Archidendron ramiflorum* (F.Muell.) Kosterm.	*Fragm.* 9(80): 178 (1875)
Gardenia hirta F.Muell. (*Atractocarpus hirtus* (F.Muell.) Puttock)	*Fragm.* 9(80): 181 (1875)
Musa fitzalanii F.Muell.	*Fragm.* 9(80): 188 (1875)
Kentia minor (W.Hill) F.Muell. (*Linospadix minor* (W.Hill) Burret)	*Fragm.* 9(80): 195 (1875)
Caesalpinia nuga (L.) W.T.Aiton (*Caesalpinia crista* L.)	*Fragm.* 10(81): 7 (1876)
Elaeocarpus grahamii F.Muell.	*Fragm.* 10(81): 3 (1876)
Jacksonia ramosissima Benth.	*Fragm.* 10(82): 37 (1876)
Tetracera wuthiana F.Muell.	*Fragm.* 10(83): 49 (1876)
Corymbis veratrifolia (Reinw.) Rchb.f. (*Corymborkis vertrifolia* (Reinw.) Blume	*Fragm.* 10(83): 64 (1876)
Leichhardtia clamboides F.Muell. (*Phyllanthus clamboides* (F.Muell.) Diels)	*Fragm.* 10(84): 68 (1876)
Ipomoea denticulata R.Br. (*Xenostegia tridentata* (L.) D.F.Austin & Staples)	*Fragm.* 10(87): 112 (1876)
Ipomoea bona-nox L. (*Ipomoea alba* L.)	*Fragm.* 10(87): 113 (1876)
Ptychosperma normanbyi (W.Hill) F.Muell. (*Normanbya normanbyi* (W.Hill) L.H.Bailey)	*Fragm.* 11: (89): 56 (1878)
Alsophila rebeccae F.Muell. (*Cyathea rebeccae* (F.Muell.) Domin)	*Fl. Austral.* 7: 710 (1878)
Alsophila australis R.Br. (*Cyathea australis* (R.Br.) Domin)	*Fl. Austral.* 7: 711 (1878)
Grammitis ampla F.Muell. ex Benth. (*Colysis ampla* (F.Muell. ex Benth.) Copel.)	*Fl. Austral.* 7: 777 (1878)
Acacia crassocarpa F.Muell. (*Acacia crassicarpa* A.Cunn. ex Benth.)	*Fragm.* 11(90): 69 (1879)
Selaginella australiensis Baker	*J. Bot.* 21: 144 (1883)
Adiantum hispidulum var. *fitzalani* Bail. [= *Adiantum diaphanum* Blume]	*Compr. Cat. Queensalnd Pl.* 641 (1913)
Musa banksii var. *muelleriana* Domin (*Musa banksii* F.Muell.)	*Biblioth. Bot.* 20(85): 536 (1915)

Table 16. Species collected by Eugene Fitzalan from the Daintree River area. The list is divided by year and plant type, either Pteridophytes or Angiosperms. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

1873-74?

Blechnum orientale L.
Cephalomanes obscurum (Blume) K.Iwats

1875, Pteridophytes

Acrostichum aureum L.
Adiantum diaphanum Blume
Angiopteris evecta (G.Forst.) Hoffm.
Antrophyum callifolium Blume
Arthropteris palisotii (Desv.) Alston
Asplenium nidus L.
Blechnum cartilagineum Sw.
Blechnum orientale L.
Bolbitis quoyana (Gaudich.) Ching
Cephalomanes atrovirens C.Presl
Christella subpubescens (Blume) Holttum
Coveniella poecilophlebia (Hook.) Tindale
Cyathea cooperi (Hook. ex F.Muell.) Domin
Cyathea rebeccae (F.Muell.) Domin
Dicranopteris linearis (Burm.f.) Underw.
Diplazium dietrichianum (Luerss.) C.Chr.
Diplazium dilatatum Blume
Doodia caudata (Cav.) R.Br.
Goniophlebium percussum (Cav.) W.H.Wagner & Grether
Goniophlebium subauriculatum (Blume) C.Presl
Helminthostachys zeylanica (L.) Kaulf.
Lycopodiella cernua (L.) Pic.Serm.
Lygodium reticulatum Schkuhr
Nephrolepis acutifolia (Desv.) H.Christ
Pronephrium asperum (C.Presl) Holttum
Pteridium esculentum x *Pteridium revolutum*
Pteris pacifica Hieron.
Pteris tremula R.Br.
Pteris tripartita Sw.
Ptisana oreades (Domin) Murdock
Pyrrosia longifolia (Burm.f.) C.V.Morton
Schizaea dichotoma (L.) Sm.
Selaginella australiensis Baker
Selaginella longipinna Warb.
Vittaria elongata Sw.

1875, Angiosperms

Acanthus ilicifolius L.
Archidendron lucyi F.Muell.
Archidendron ramiflorum (F.Muell.) Kosterm.
Atractocarpus fitzalanii (F.Muell.) Puttock subsp. *fitzalanii*
Atractocarpus hirtus (F.Muell.) Puttock
Barringtonia racemosa (L.) Spreng.
Breynia cernua (Poir.) Mull.Arg.
Caesalpinia crista L.
Calamus sp.
Casearia dallachii F.Muell.
Centotheca lappacea (L.) Desv.
Cerbera floribunda K.Schum.
Cleistanthus apodus Benth.
Commersonia macrostipulata Guymer
Connarus conchocarpus F.Muell. subsp. *conchocarpus*
Cordyline cannifolia R.Br.
Cryptocarya triplinervis var. *riparia* B.Hyland
Cyperus gunii Hook.f.
Cyrtococcum oxyphyllum (Hochst. ex Steud.) Stapf
Dapsilanthus ramosus (R.Br.) B.G.Briggs & L.A.S.Johnson
Dapsilanthus spathaceus (R.Br.) B.G.Briggs & L.A.S.Johnson
Davidsonia pruriens F.Muell.
Dioclea hexandra (Ralph) Mabb.
Diploglottis sp.
Dodonaea polyandra Merr. & L.M.Perry
Durandea jenkinsii (F.Muell.) Stapf
Dysoxylum spp
Echinochloa dietrichiana P.W.Michael
Eustrephus latifolius R.Br. ex Ker Gawl.
Flagellaria indica L.
Floscopa scandens Lour.
Garovaglia powellii subsp. *muelleri* (Hampe) During
Harpullia rhyticarpa C.T.White & W.D.Francis
Hetaeria sp.
Hibiscus tiliaceus L.
Hydriastele wendlandiana (F.Muell.) H.Wendl. & Drude
Hypolytrum latifolium Rich. ex Pers.
Ipomoea alba L.
Ipomoea gracilis R.Br.
Leptochloa fusca (L.) Kunth subsp. *fusca*
Leptochloa sp.
Lithomyrtus obtusa (Endl.) N.Snow & Guymer
Melaleuca sp.
Melastoma malabathricum L. subsp. *malabathricum*
Millettia pinnata (L.) Panigrahi
Morinda sp.
Musa banksii F.Muell.
Musa fitzalanii F.Muell.
Musa jackeyi W.Hill
Normanbya normanbyi (W.Hill) L.H.Bailey
Orthosiphon aristatus (Blume) Miq.
Panicum trichoides Sw.
Plectranthus foetidus Benth.
Pleuranthodium racemigerum (F.Muell.) R.M.Sm.
Pollia macrophylla (R.Br.) Benth.
Pothos longipes Schott
Pseuderanthemum variabile (R.Br.) Radlk.
Rhysotoechia robertsonii (F.Muell.) Radlk.
Schoenoplectus mucronatus (L.) Palla ex J.Kern
Scirpodendron ghaeri (Gaertn.) Merr.
Solanum dallachii Benth.
Syzygium angophoroides (F.Muell.) B.Hyland
Syzygium hemilamprum (F.Muell.) Craven & Biffin subsp. *hemilamprum*
Tabernaemontana pandacaqui Lam.
Tapeinochilos ananassae (Hassk.) K.Schum.
Tectaria confluens (F.Muell. ex Baker) Pic.Serm.
Tournefortia sarmentosa Lam.
Trema tomentosa var. *viridis* (Planch.) Hewson
Tristaniopsis exiliflora (F.Muell.) Peter G.Wilson & J.T.Waterh.
Vigna sp.
Youngia japonica (L.) DC.

1876, Angiosperms

Acacia crassicarpa A.Cunn. ex Benth.
Aleurites rockinghamensis (Baill.) P.I.Forst.
Ampelocissus acetosa L.
Archidendron ramiflorum (F.Muell.) Kosterm.
Atractocarpus sessilis (F.Muell.) Puttock
Banksia sp.
Barringtonia sp.
Bombax ceiba var. *leiocarpum* A.Robyns
Cananga odorata (Lam.) Hook.f. & Thomson
Cucuma australasica Hook.f.
Cyclophyllum maritimum S.T.Reynolds & R.J.F.Hend.
Davidsonia pruriens F.Muell.
Dillenia alata (DC.) Martelli
Erythrophleum chlorostachys (F.Muell.) Baill.

Eucalyptus leptophleba F.Muell.
Eupomatia laurina R.Br.
Gmelina dalrympleana (F.Muell.) H.J.Lam
Hakea pedunculata F.Muell.
Lophostemon suaveolens (Sol. ex Gaertn.) Peter G.Wilson & J.T.Waterh.
Mischocarpus grandissimus (F.Muell.) Radlk.
Pandanus solmslaubachii F.Muell.
Platysace valida (F.Muell.) F.Muell.
Pleomele angustifolia (Medik.) N.E.Br.
Polyscias australiana (F.Muell.) Philipson
Syzygium tiernayanum (F.Muell.) T.G.Hartley & L.M.Perry
Tetracera nordtiana F.Muell. var. *nordtiana*
Tristaniopsis exiliflora (F.Muell.) Peter G.Wilson & J.T.Waterh.

1880, 1882

Adiantum diaphanum Blume
Derris sp.

Undated, Pteridophytes

Adiantum hispidulum Sw.
Adiantum silvaticum Tindale
Arthropteris palisotii (Desv.) Alston
Asplenium laserpitiifolium Lam.
Blechnum orientale L.
Calochlaena dubia (R.Br.) M.D.Turner & R.A.White
Dicranopteris linearis (Burm.f.) Underw. var. *linearis*
Dicranopteris linearis var. *altissima* Holttum
Diplazium dameriae Pic.Serm.
Diplazium dietrichianum (Luerss.) C.Chr.
Lomariopsis kingii (Copel.) Holttum
Pronephrium asperum (C.Presl) Holttum
Pteris marginata Bory
Pteris pacifica Hieron.
Selaginella australiensis Baker
Selaginella longipinna Warb.

Undated, Angiosperms

Blumea lacera (Burm.f.) DC.
Caesalpinia subtropica Pedley
Centotheca lappacea (L.) Desv.
Cyperus odoratus L.
Cyrtococcum oxyphyllum (Hochst. ex Steud.) Stapf
Doryphora aromatica (F.M.Bailey) L.S.Sm.
Elaeocarpus grahamii F.Muell.
Entada rheedii Spreng.
Eucalyptus leptophleba F.Muell. subsp. *leptophleba*
Eucalyptus pellita F.Muell.
Gillbeea whypallana Rozefelds & Pellow
Homalanthus populifolius Graham
Hoya pottsi Traill
Linospadix minor (W.Hill ex F.Muell.) F.Muell.
Melastoma malabathricum L. subsp. *malabathricum*
Mischocarpus grandissimus (F.Muell.) Radlk.
Musa jackeyi W.Hill
Panicum trichoides Sw.
Phyllanthus clamboides (F.Muell.) Diels
Pittosporum rubiginosum A.Cunn.
Plectranthus spectabilis S.T.Blake
Rourea brachyandra F.Muell.
Syzygium tiernayanum (F.Muell.) T.G.Hartley & L.M.Perry
Tetracera nordtiana var. *wuthiana* (F.Muell.) Hoogland

General botanical collections

During the periods when Fitzalan was not engaged in longer expeditions or excursions, he consistently collected plant specimens from near his residences or during incidental travel. Table 17 presents the type specimens related to collections he made around Port Denison (Bowen) during the period 1860 to 1886. Table 18 lists additional type specimens collected from locations not already listed. Species collected in Tasmania (Mueller1869), ca 1853–1854 are listed in Table 19, and those collected from around Brisbane, labelled as Moreton Bay and Pine River, ca 1860 are listed in Table 20. Table 21 lists species collected at Port Denison, Bowen and Edgecumbe Bay and species collected in the upper Burdekin River are listed in Table 22. Species collected in the Cairns, Trinity Bay and Port Douglas areas are listed in Table 23 and those from Cooktown in Table 24. Species without a designated location are listed in Table 25.

Conclusion

Eugene Fitzalan holds a significant place in the development of botanical research in Queensland. For the period in which he was active [1860–1890], his number of collections (about 2200 specimens), places him in the group of the most active botanical collectors. Many of his collections represent the first botanical excursions to a number of localities, such as Mt Dryander, Mt Elliot and Daintree River. In as such, his specimens represent an example of the species that were present at that time and offer the potential to compare with extant species compositions for those areas. Fitzalan's contribution to horticulture was also significant. He was active in establishing a number of private gardens, as well as public gardens in Bowen and Cairns. The Cairns Botanical Gardens is now an internationally recognised heritage-listed facility featuring tropical plants. He introduced a number of species into horticulture, such as *Atractocarpus fitzalanii* [brown Gardenia], *Hymeneria fitzalanii* [common fuzz orchid] and *Cycas* species, which are today of significant importance in commercial and amenity horticulture. This work has placed Fitzalan into an historical context, with regard to details of his excursions and the plant species that he collected.

Table 17. Type specimens collected by Eugene Fitzalan in the Port Denison (Bowen) area, 1860–1886. Original species names are retained and the currently used name follows in parentheses. Collections list the location and the specimens relevant to typification, but the status of the typification is not provided as it is beyond the scope of this work. The publication details of the protologue are provided. Taxonomy follows that presented in Australian Plant Census (2014), Australian Plant Name Index (2014) and Guiry & Guiry (2014).

Taxon	**Collections**	**Publication**
Sargassum ambiguum Sond. (*Sargassum polycystum* C.Agardh)	Port Denison, *Fitzalan*; MEL0688742	*Abh. Verh. Naturwiss. Vereins Hamburg* 5: 41 (1871)
Sargassum cristaefolium var. *condensatum* Sond.	Port Denison, *Fitzalan*; No specimens located	*Abh. Verh. Naturwiss. Vereins Hamburg* 5: 42 (1871)
Gracilaria polyclada Sond. (*Hydropuntia edulis* (Gmel.) Gurgel & Fredericq)	Port Denison, *Fitzalan*; MEL0629918, 0629887	*Abh. Verh. Naturwiss. Vereins Hamburg* 5: 56 (1871)
Dicranema setaceum Sond. (*Sarconema filiforme* (Sond.) Kylin)	Port Denison, *Fitzalan*; No specimens located	*Abh. Verh. Naturwiss. Vereins Hamburg* 5: 58 (1871)
Sarcopetalum brahei F.Muell. (*Miliusa brahei* (F.Muell.) Jessup)	Port Denison, 1874, *Fitzalan*; BRIAQ0332779, MEL0234171, MEL0234172	*Fragm.* 8(66): 159 (1874)
Cycas normanbyana F.Muell. (*Cycas media* R.Br.)	Port Denison, April 1874, *Fitzalan*; MEL0269419	*Fragm.* 8(66): 169 (1874)
Alyxia thyrsiflora Benth. (*Alyxia spicata* R.Br.)	Port Denison, *Dallachy & Fitzalan*; K000894092, MEL0223096 – 0223097, W0049218	*Fl. Austral.* 4: 309 (1868)
Helichrysum boormanii var. *tryonii* Domin (*Coronidium lanuginosum* (A.Cunn. ex DC) Paul G. Wilson)	Port Denison, 1874, *Fitzalan*; MEL0262825, MEL0262827	*Biblioth. Bot.* 22(89): 1124 (1930)
Ptilotus dissitiflorus var. *longifolius* Benl (*Ptilotus nobilis* var. *semilanatus* (Lindl.) A.R.Bean)	Port Denison, 1874, Fitzalan; MEL2282812, MEL2281813	*Muelleria* 1(2): 107 (1959)
Macropteranthes fitzalanii F.Muell.	Port Denison, *Fitzalan*; K000786635, MEL1005516	*Fragm.* 8(66): 160 (1874)
Muehlenbeckia rhyticarya F.Muell. ex Benth.	Port Denison, *Fitzalan*; K000831375	*Fragm.* 5(35): 92 (1865)
Claoxylon angustifolium Mull.Arg.	Port Denison (F.Mueller in herb DC); MEL0707739	*Linnaea* 34: 165 (1865)
Myrtus racemulosa var. *conferta* Benth. (*Gossia bidwillii* (Benth.) N.Snow & Guymer)	Port Denison, *Fitzalan*; K000821466, MEL0092365 – 0092367, MEL0092370 – 0092372	*Fl. Austral.* 3: 276 (1867)
Pluchea dentex Benth.	Port Denison, *Fitzalan*; DNAD0061619, MEL1621083	*Fl. Austral.* 3: 529 (1867)
Hypoestes floribunda subsp. *densiflora* Benth. (*Hypoestes floribunda* var. *pubescens* Benth.)	Port Denison, *Fitzalan*; MEL0601956	*Fl. Austral.* 4: 554 (1868)
Andropogon sericeus var. *polystachyus* Benth. (*Dichanthium sericeum* var. *polystachyum* (Benth.) B.K.Simom)	Port Denison, *Fitzalan*; MEL1547445, MEL1547456 – 1547458	*Fl. Austral.* 7: 530 (1878)
Chrysopogon parviflorus var. *spicigerus* Benth. (*Capillipedium spicigerum* S.T.Blake)	Port Denison, *Fitzalan*; MEL1546073	*Fl. Austral.* 7: 538 (1878)
Cyperus fulvus var. *canescens* (C.B.Clarke ex Domin (*Cyperus fulvus* R.Br.)	Port Denison, *Fitzalan*; MEL2197982	*Pflanzenr.* 101: 456 (1936)
Ficus platypoda var. *petiolaris* Benth. (*Ficus rubiginosa* Desf. ex Vent.	Port Denison, *Fitzalan*; MEL0239478	*Fl. Austral.* 6:170 (1873)

Table 18. Type specimen collected by Eugene Fitzalan, not accounted for elsewhere. Original species names are retained and the currently used name follows in parentheses. Collections list the location and the specimens relevant to typification, but the status of the typification is not provided as it is beyond the scope of this work. The publication details of the protologue are provided. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Taxon	**Collections**	**Publications**
Ledgeria foliata F.Muell. (*Pseudovanilla foliata* (F.Muell.) Garay)	Pine River, *Fitzalan*; MEL0677528-MEL0677531	*Fragm.* 2(16): 167 (1861)
Desmodium nemorosum F.Muell. ex Benth.	Pine River, *Fitzalan* MEL2126066	*Fl. Austral.* 2: 232 (1864)
Myrtus hillii Benth. (*Gossia hillii* (Benth.) N.Snow & Guymer)	Moreton Bay, *Fitzalan*; MEL0092357; NSW144690; NSW144689	*Fl. Austral.* 3: 275 (1867)
Hibiscus elsworthii F.Muell. [APC excluded name]	Edgecumbe Bay, *Fitzalan*; No specimens located	*Fragm.* 8(70: 241 (1874)
Eucalyptus torelliana F.Muell.) (*Corymbia torelliana* F.Muell.) K.D.Hill & L.A.S.Johnson)	Trinity Bay, 1877, *Fitzalan*; MEL1610979	*Fragm.* 10(87): 106 (1877)
Eugenia myrsinocarpa F.Muell. (*Gossia myrsinocarpa* (F.Muell.) N.Snow & Guymer)	Trinity Bay, 1877, *Fitzalan*; MEL0060539, MEL0060540	*Vict. Naturalist* 8(12): 200 (1892).
Lepistemon fitzalanii F.Muell. (*Lepistemon urceolatus* (R.Br.) F.Muell.)	Trinity Bay, *Fitzalan*; MEL0304420, MEL0304420	*Fragm.* 10(87): 111 (1877)
Eria fitzalanii F.Muell. (*Hymeneria fitzalanii* (F.Muell.) M.A.Clem. & D.L.Jones)	Mulgrave River, Fitzalan; No specimens located in MEL	*S. Sci. Rec.* 2(11): 252 (1882)
Cycas kennedyana F.Muell. (*Cycas media* R.Br. var. *media*)	Normanby Ranges, 1881, *Fitzalan*; MEL0269419	*Australas. Chem. Drugg.* 4: 85 (1882)

Table 19. Species collected by Eugene Fitzalan in Tasmania, ca 1853–1854. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Acacia oxycedrus Sieber ex DC.
Aotus ericoides (Vent.) G.Don
Callistemon sieberi DC.
Correa backhouseana Hook. var. *backhouseana*
Correa glabra Lindl.
Correa reflexa (Labill.) Vent. var. *reflexa*
Daviesia ulicifolia Andrews subsp. *ulicifolia*
Dillwynia cinerascens R.Br.
Epacris impressa Labill.
Gentianella gunniana (L.G.Adams) Glenny
Gompholobium huegelii Benth.
Gynatrix pulchella (Willd.) Alef.
Leptospermum lanigerum (Sol. ex Aiton) Sm.
Leucopogon australis R.Br.
Melaleuca ericifolia Sm.
Melaleuca squarrosa Donn ex Sm.
Ozothamnus ferrugineus (Labill.) Sweet
Pimelea ligustrina Labill. subsp. *ligustrina*
Pimelea linifolia Sm. subsp. *linifolia*
Pultenaea gunnii Benth. subsp. *gunnii*
Viminaria juncea (Schrad. & J.C.Wendl.) Hoffmanns.

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Table 20. Species collected by Eugene Fitzalan in the Moreton Bay and Pine River areas, ca 1860. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Acacia fimbriata A.Cunn. ex G.Don
Acacia maidenii F.Muell.
Acacia paradoxa DC.
Acacia suaveolens (Sm.) Willd.
Acacia ulicifolia (Salisb.) Court
Acacia uncifolia (J.M.Black) OLeary
Adiantum aethiopicum L.
Adiantum formosum R.Br.
Alyxia buxifolia R.Br.
Alyxia ruscifolia R.Br.
Aphanopetalum resinosum Endl.
Arytera divaricata F.Muell.
Astrotricha longifolia Benth.
Atalaya multiflora Benth.
Backhousia myrtifolia Hook. & Harv.
Boronia rosmarinifolia A.Cunn. ex Endl.
Bursaria spinosa Cav. subsp. *spinosa*
Bursaria tenuifolia F.M.Bailey
Callicarpa pedunculata R.Br.
Callistemon viminalis (Sol. ex Gaertn.) G.Don ex Loudon
Capparis arborea (F.Muell.) Maiden
Castanospermum australe A.Cunn. & C.Fraser ex Hook.
Cenchrus caliculatus Cav.
Chamaecrista concinna (Benth.) Pedley
Cissus hypoglauca A.Gray
Citrus australasica F.Muell.
Coelospermum paniculatum F.Muell. var. *paniculatum*
Comesperma defoliatum F.Muell.
Commersonia bartramia (L.) Merr.
Conospermum taxifolium C.F.Gaertn.
Cordyline petiolaris (Domin) Pedley
Corymbia gummifera (Gaertn.) K.D.Hill & L.A.S.Johnson
Cryptocarya laevigata Blume
Daviesia squarrosa Sm.
Daviesia villifera A.Cunn. ex Benth.
Deeringia amaranthoides Merrill
Deeringia arborescens Domin
Desmodium nemorosum F.Muell. ex Benth.
Dianella caerulea Sims
Dianella longifolia R.Br.
Dicranopteris linearis (Burm.f.) Underw.
Dodonaea triquetra J.C.Wendl.
Doodia media R.Br.
Elaeocarpus reticulatus Sm.
Epacris microphylla R.Br.
Erythrina vespertilio Benth.
Eucalyptus acmenoides Schauer
Eupomatia laurina R.Br.
Glycine clandestina J.C.Wendl.
Goodenia ovata Sm.
Gossia bidwillii (Benth.) N.Snow & Guymer
Gossia hillii (Benth.) N.Snow & Guymer
Gratiola peruviana L.
Hardenbergia violacea (Schneev.) Stearn
Hibiscus heterophyllus Vent. subsp. *heterophyllus*
Holcus lanatus L.
Hovea acutifolia A.Cunn. ex G.Don
Hybanthus stellarioides (Domin) P.I.Forst.
Hymenosporum flavum (Hook.) F.Muell.
Indigofera australis Willd. subsp. *australis*
Indigofera decora Lindl.
Jacksonia scoparia R.Br. ex Sm.
Kennedia rubicunda (Schneev.) Vent.
Lastreopsis munita (Mett.) Tindale
Leucopogon pimeleoides A.Cunn. ex DC.
Lindsaea fraseri Hook.
Lobelia gibbosa Labill.
Lophostemon confertus (R.Br.) Peter G.Wilson & J.T.Waterh.
Lophostemon suaveolens (Sol. ex Gaertn.) Peter G.Wilson & J.T.Waterh.
Lysiana exocarpi (Behr.) Tiegh.
Lythrum salicaria L.
Mallotus philippensis (Lam.) Mull.Arg.
Medicosma cunninghamii (Hook.) Hook.f.
Melaleuca bracteata F.Muell.
Melaleuca sieberi Schauer
Melastoma malabathricum L. subsp. *malabathricum*
Ozothamnus diosmifolius (Vent.) DC.
Pandorea floribunda (A.Cunn. ex DC.) Guymer
Pararchidendron pruinosum (Benth.) I.C.Nielsen var. *pruinosum*
Parsonsia straminea (R.Br.) F.Muell.
Pavetta australiensis Bremek. var. *australiensis*
Persoonia cornifolia A.Cunn. ex R.Br.
Persoonia falcata R.Br.
Persoonia stradbrokensis Domin
Phyllota phylicoides (Sieber ex DC.) Benth.
Pimelea linifolia Sm. subsp. *linifolia*
Pittosporum revolutum Dryand.
Plumbago zeylanica L.
Pollia crispata Benth.
Pothos longipes Schott
Proiphys cunninghamii (Aiton ex Lindl.) Mabb.
Pseuderanthemum variabile (R.Br.) Radlk.
Pterocaulon sphacelatum (Labill.) F.Muell.
Rhodomyrtus psidioides (G.Don) Benth.
Rubus rosifolius Sm. var. *rosifolius*
Sambucus australasica (Lindl.) Fritsch
Sambucus gaudichaudiana DC.
Smilax australis R.Br.
Sophora fraseri Benth.
Stenocarpus sinuatus (Loudon) Endl.
Stephania japonica var. discolor (Blume) Forman
Syzygium floribunda F.Muell.
Syzygium smithii (Poir.) Nied.
Tabernaemontana pandacaqui Lam.
Turraea pubescens Hell.
Vigna vexillata var. *angustifolia* (Schumach. & Thonn.) Baker
Viola hederacea Labill. subsp. *hederacea*
Vitex trifolia L. var. *trifolia*
Wilkiea macrophylla (R.Cunn.) A.DC.
Zanthoxylum brachyacanthum F.Muell.

Table 21. Species collected by Eugene Fitzalan at Port Denison, Bowen and Edgecumbe Bay. Taxonomy follows that presented in Australian Plant Census (2014), Australian Plant Name Index (2014) and Guiry & Guiry (2014).

Abroma fastuosa R.Br.
Abrus precatorius L. subsp. *precatorius*
Acacia decora Rchb.
Acacia excelsa Benth. subsp. *excelsa*
Acacia holosericea A.Cunn. ex G.Don
Acacia julifera Benth.
Acacia leptocarpa A.Cunn. ex Benth.
Acacia leptostachya Benth.
Acacia maidenii F.Muell.
Acacia multisiliqua (Benth.) Maconochie
Acacia oswaldii F.Muell.
Acacia pendula A.Cunn. ex G.Don
Acacia salicina Lindl.
Acanthus ilicifolius L.
Acronychia laevis J.R.Forst. & G.Forst.
Adiantum aethiopicum L.
Adiantum formosum R.Br.
Adiantum hispidulum Sw.
Aegialitis annulata R.Br.
Aeschynomene brevifolia L.f. ex Poir.
Aidia racemosa (Cav.) Tirveng.
Ailanthus triphysa (Dennst.) Alston
Albizia canescens Benth.
Albizia procera (Roxb.) Benth.
Alectryon coriaceus (Benth.) Radlk.
Allocasuarina littoralis (Salisb.) L.A.S.Johnson
Allocasuarina torulosa (Aiton) L.A.S.Johnson
Alocasia brisbanensis (F.M.Bailey) Domin
Alphitonia incana (Roxb.) Teijsm. & Binn. ex Kurz
Alstonia constricta F.Muell.
Alstonia scholaris (L.) R.Br.
Alyxia ruscifolia R.Br.
Alyxia spicata R.Br.
Ampelopteris prolifera (Retz.) Copel.
Antidesma parvifolium Thwaites & F.Muell.
Argophyllum lejourdanii F.Muell.
Argyrodendron polyandrum L.S.Sm.
Argyrodendron trifoliolatum F.Muell.
Artanema fimbriatum D.Don
Arthropteris tenella (G.Forst.) J.Sm. ex Hook.f.
Arytera distylis (F.Muell. ex Benth.) Radlk.
Arytera divaricata F.Muell.
Atalaya hemiglauca (F.Muell.) F.Muell. ex Benth.
Atalaya rigida S.T.Reynolds
Austrosteenisia blackii (F.Muell.) R.Geesink var. *blackii*
Baloghia inophylla (G.Forst.) P.S.Green
Basilicum polystachyon (L.) Moench.
Bauhinia hookeri F.Muell.
Blechnum cartilagineum Sw.
Bosistoa pentacocca var. *connaricarpa* (Domin) T.G.Hartley
Bothriochloa bladhii (Retz.) S.T.Blake subsp. *bladhii*
Brachychiton acerifolius (A.Cunn. ex G.Don) Macarthur & C.Moore
Brachychiton bidwillii Hook.
Brachychiton compactus Guymer
Breynia cernua (Poir.) Mull.Arg.
Brunoniella acaulis (R.Br.) Bremek. subsp. *acaulis*
Buchnera linearis R.Br.
Buchnera tetragona R.Br.
Bursaria incana Lindl.
Bursaria tenuifolia F.M.Bailey
Caesalpinia bonduc (L.) Roxb.
Cajanus confertiflorus F.Muell.
Cajanus marmoratus (R.Br. ex Benth.) F.Muell.
Cajanus reticulatus var. *grandifolius* (F.Muell.) Maesen
Callicarpa candicans (Burm.f.) Hochr.
Callicarpa pedunculata R.Br.
Callistemon viminalis (Sol. ex Gaertn.) G.Don ex Loudon
Calochlaena dubia (R.Br.) M.D.Turner & R.A.White
Calophyllum inophyllum L.
Calytrix microcoma Craven
Camptacra gracilis (Benth.) Lander
Canarium australianum F.Muell. var. *australianum*
Capillipedium spicigerum S.T.Blake
Capparis canescens Banks ex DC.
Capparis lasiantha R.Br. ex DC.
Capparis lucida (Banks ex DC.) Benth.
Capparis ornans F.Muell. ex Benth.
Capparis sepiaria L.
Capparis umbonata Lindl.
Cardiospermum halicacabum L. var. *halicacabum*
Carissa ovata R.Br.
Cartonema brachyantherum Benth.
Cassia brewsteri (F.Muell.) Benth.
Casuarina cunninghamiana Miq. subsp. *cunninghamiana*
Casuarina equisetifolia L. subsp. *equisetifolia*
Caulerpa cupressoides (Vahl) C.Agardh
Celtis philippensis Blanco var. *philippensis*
Ceratophyllum demersum L.
Cerbera manghas L.
Chamaecrista absus (L.) H.S.Irwin & Barneby
Chamaecrista mimosoides (L.) Greene
Chamaesyce macgillivrayi (Boiss.) D.C.Hassall
Cheilanthes tenuifolia (Burm.f.) Sw.
Chrysopogon fallax S.T.Blake
Claoxylon angustifolium Mull.Arg.
Clausena brevistyla Oliv.
Clematicissus opaca (F.Muell.) Jackes & Rossetto
Clerodendrum floribundum var. *angustifolium* Moldenke
Clerodendrum floribundum var. *coriaceum* (R.Br.) Moldenke
Clerodendrum floribundum var. *ovatum* (R.Br.) Domin
Clerodendrum inerme (L.) Gaertn.
Cochlospermum gillivraei Benth.
Coelospermum reticulatum (F.Muell.) Benth.
Colocasia esculenta (L.) Schott
Colubrina asiatica (L.) Brongn. var. *asiatica*
Commersonia bartramia (L.) Merr.
Cordia dichotoma G.Forst.
Cordia subcordata Lam.
Cordyline manners-suttoniae F.Muell.
Cordyline murchisoniae F.Muell.
Coronidium elatum (A.Cunn. ex DC.) Paul G.Wilson
Coronidium lanuginosum (A.Cunn. ex DC.) Paul G.Wilson
Corymbia citriodora (Hook.) K.D.Hill & L.A.S.Johnson
Corymbia clarksoniana (D.J.Carr & S.G.M.Carr) K.D.Hill & L.A.S.Johnson
Corymbia gummifera (Gaertn.) K.D.Hill & L.A.S.Johnson
Corymbia polycarpa (F.Muell.) K.D.Hill & L.A.S.Johnson
Coveniella poecilophlebia (Hook.) Tindale
Crinum angustifolium R.Br.
Crotalaria calycina Schrank
Crotalaria juncea L.
Crotalaria laburnifolia L.
Crotalaria medicaginea var. *neglecta* (Wight & Arn.) Baker
Crotalaria mitchellii Benth. subsp. *mitchellii*
Crotalaria montana var. *angustifolia* (Gagnep.) Niyomdham
Crotalaria verrucosa L.
Croton acronychioides F.Muell.
Croton arnhemicus Mull.Arg.
Croton phebalioides F.Muell. ex Mull.Arg.
Cryptocarya triplinervis R.Br. var. *triplinervis*
Cullen australasicum (Schltdl.) J.W.Grimes
Cullen leucanthum (F.Muell.) J.W.Grimes
Cyanthillium cinereum (L.) H.Rob.
Cyathea cooperi (Hook. ex F.Muell.) Domin

Cyathea rebeccae (F.Muell.) Domin
Cycas media R.Br. subsp. *media*
Cymbopogon bombycinus (R.Br.) Domin
Cymodocea rotundata (Ehrenb. & Hempr. ex Asch.) Asch. & Scweinf.
Cyperus exaltatus Retz.
Cyperus fulvus R.Br.
Cyperus iria L.
Cyperus nervulosus (Kuk.) S.T.Blake
Cyperus nutans subsp. *eleusinoides* (Kunth) T.Koyama
Cyperus ramosus (Benth.) Kuk.
Dactyloctenium aegyptium (L.) P.Beauv.
Dactyloctenium radulans (R.Br.) P.Beauv.
Dampiera ferruginea R.Br.
Deeringia amaranthoides Merrill
Deeringia arborescens Domin
Dendrocnide moroides (Wedd.) Chew
Dendrolobium umbellatum (L.) Benth.
Dendrophthoe glabrescens (Blakely) Barlow
Dendrophthoe vitellina (F.Muell.) Tiegh.
Denhamia cunninghamii (Hook.) M.P.Simmons
Denhamia disperma (F.Muell.) M.P.Simmons
Denhamia oleaster (Lindl.) F.Muell.
Dianella longifolia R.Br.
Dichanthium sericeum subsp. *polystachyum* (Benth.) B.K.Simon
Dictyota dichotoma (Huds.) J.V.Lamour. var. *dichotoma*
Dioscorea transversa R.Br.
Diospyros australis (R.Br.) Hiern
Diospyros geminata (R.Br.) F.Muell.
Diospyros humilis (R.Br.) F.Muell.
Dipteracanthus australasicus F.Muell. subsp. *australasicus*
Dodonaea lanceolata var. *subsessilifolia* J.G.West
Doodia aspera R.Br.
Doodia caudata (Cav.) R.Br.
Doryopteris concolor (Langsd. & Fisch.) Kuhn
Drosera indica L.
Drynaria quercifolia (L.) J.Sm.
Drynaria rigidula (Sw.) Bedd.
Drypetes deplanchei (Brongn. & Gris) Merr.
Dysoxylum gaudichaudianum (A.Juss.) Miq.
Dysoxylum rufum (A.Rich.) Benth.
Echinochloa dietrichiana P.W.Michael
Ehretia acuminata R.Br. var. *acuminata*
Ehretia acuminata var. *pilosula* (F.Muell.) I.M.Johnst.
Elaeagnus triflora Roxb. var. *triflora*
Elaeodendron melanocarpum F.Muell.
Elattostachys bidwillii (Benth.) Radlk.
Entada rheedii Spreng.
Epipremnum pinnatum (L.) Engl.
Eragrostis elongata (Willd.) Jacq.
Eragrostis tenellula (Kunth) Steud.
Eremophila mitchellii Benth.
Eremophila polyclada (F.Muell.) F.Muell.
Erythrina variegata L.
Erythrina vespertilio Benth.
Erythroxylum australe F.Muell.
Eucalyptus crebra F.Muell.
Eucalyptus persistens L.A.S.Johnson & K.D. Hill
Eucalyptus platyphylla F.Muell.
Eucalyptus raveretiana F.Muell.
Eucalyptus tereticornis Sm.
Eucheuma denticulatum (Burm.f.) Collins & Herv.
Eugenia reinwardtiana (Blume) DC.
Euphorbia hirta L.
Euphorbia mitchelliana Boiss. var. *mitchelliana*
Eustrephus latifolius R.Br. ex Ker Gawl.
Exocarpos latifolius R.Br.
Ficus copiosa Steud.
Ficus hispida L.f. var. *hispida*
Ficus opposita Miq.
Ficus racemosa L. var. *racemosa*
Ficus rubiginosa Desf. ex Vent. f. *rubiginosa*
Fimbristylis microcarya F.Muell.
Flemingia lineata (L.) Roxb. ex W.T.Aiton
Flindersia schottiana F.Muell.
Flueggea virosa subsp. *melanthesoides* (F.Muell.) G.L.Webster
Ganophyllum falcatum Blume
Gastrolobium grandiflorum F.Muell.
Geijera salicifolia Schott
Geodorum densiflorum (Lam.) Schltr.
Glinus oppositifolius (L.) A.DC.
Glycosmis trifoliata (Blume) Spreng.
Gomphrena humilis R.Br.
Goniophlebium percussum (Cav.) W.H.Wagner & Grether
Gossia bidwillii (Benth.) N.Snow & Guymer
Gossypium australe F.Muell.
Grevillea parallela Knight
Grevillea pteridifolia Knight
Grevillea striata R.Br.
Grewia oxyphylla Burret
Grewia retusifolia Kurz
Guettarda speciosa L.
Gymnanthera oblonga (Burm.f.) P.S.Green
Gynura drymophila (F.Muell.) F.G.Davies var. drymophila
Gyrocarpus americanus Jacq.
Hakea lorea (R.Br.) R.Br. subsp. lorea
Halicoryne spicata (Kuetz.) Solms
Halodule uninervis (Forssk.) Asch.
Halophila spinulosa (R.Br.) Asch.
Hanslia ormocarpoides (DC.) H.Ohashi
Harnieria hygrophiloides (F.Muell.) R.M.Barker
Harpullia pendula Planch. ex F.Muell.
Heliotropium muelleri (I.M.Johnst.) Craven
Heliotropium ovalifolium Forssk.
Heliotropium sarmentosum (Lam.) Craven
Heliotropium ventricosum R.Br.
Helminthostachys zeylanica (L.) Kaulf.
Hibiscus heterophyllus Vent. subsp. *heterophyllus*
Hibiscus meraukensis Hochr.
Hibiscus sturtii Hook. var. *sturtii*
Hibiscus tiliaceus L.
Homalanthus populifolius Graham
Homalium circumpinnatum F.M.Bailey
Hoya australis R.Br. ex Traill subsp. *australis*
Hydropuntia edulis (S.G.Gmel.) Gurgel & Fredericq
Hydropuntia urvillei Montagne
Hypericum gramineum G.Forst.
Hypnea nidifica J.Agardh
Hypnea pannosa J.Agardh
Hypnea rugulosa Mont.
Hypnea spinella (C.Agardh) Kuetz.
Hypoestes floribunda R.Br. var. *floribunda*
Hypoestes floribunda var. *pubescens* Benth.
Ipomoea eriocarpa R.Br.
Jacksonia ramosissima Benth.
Jacquemontia paniculata (Burm.f.) Hallier f.
Jania micrarthrodia J.V.Lamour.
Jasminum didymum G.Forst. subsp. *didymum*
Jasminum didymum subsp. *racemosum* (F.Muell.) P.S.Green
Jasminum simplicifolium subsp. *australiense* P.S.Green
Labichea nitida Benth.
Lagunaria queenslandica Craven
Lastreopsis tenera (R.Br.) Tindale
Laurencia brongniartii J.Agardh
Laurencia dendroidea J.Agardh
Leea indica (Burm.f.) Merr.
Lepiderema punctulata (F.Muell.) Radlk.
Leptospermum neglectum Joy Thomps.
Leptospermum polygalifolium Salisb.
Limnophila brownii Wannan
Limonium solanderi (L.) Mill.
Lindernia crustacea (L.) F.Muell.
Lithomyrtus obtusa (Endl.) N.Snow & Guymer

Litsea glutinosa (Lour.) C.B.Rob.
Lomandra multiflora (R.Br.) Britten subsp. *multiflora*
Lophostemon grandiflorus subsp. *riparius* (Domin) Peter G.Wilson & J.T.Waterh.
Ludwigia octovalvis (Jacq.) P.H.Raven
Lysiana spathulata (Blakely) Barlow subsp. spathulata
Lysiana subfalcata (Hook.) Barlow
Lythrum hyssopifolia L.
Macaranga involucrata (Wall.) Baill. ex Mull.Arg.
Macaranga tanarius (L.) Mull.Arg.
Macropteranthes fitzalanii F.Muell.
Meiogyne heteropetala (F.Muell.) D.C.Thomas, Chaowasku & R.M.K.Saunders
Melaleuca dealbata S.T.Blake
Melaleuca leucadendra (L.) L.
Melaleuca nervosa (Lindl.) Cheel
Melaleuca viridiflora Sol. ex Gaertn.
Melanamansia glomerata (C.Agardh) R.E.Norris
Melastoma malabathricum L. subsp. *malabathricum*
Melia azedarach L.
Melodorum leichhardtii (F.Muell.) Benth.
Memecylon pauciflorum Blume var. *pauciflorum*
Micromelum minutum (G.Forst.) Wight & Arn.
Miliusa brahei (F.Muell.) Jessup
Millettia pinnata (L.) Panigrahi
Mimusops elengi L.
Mischocarpus stipitatus S.T.Reynolds
Monochoria cyanea (F.Muell.) F.Muell.
Monococcus echinophorus F.Muell.
Murdannia gigantea (Vahl.) G.Brueckn.
Murraya paniculata (L.) Jack
Myrsine variabilis R.Br.
Nauclea orientalis (L.) L.
Neolitsea brassii C.K.Allen
Nephrolepis acutifolia (Desv.) H.Christ
Nephrolepis biserrata (Sw.) Schott
Nephrolepis hirsutula (G.Forst.) C.Presl
Niemeyera antiloga (F.Muell.) T.D.Penn.
Notelaea microcarpa R.Br.
Ochrosia elliptica Labill.
Oldenlandia galioides (F.Muell.) F.Muell.
Orthosiphon aristatus (Blume) Miq.
Pandorea linearis (F.M.Bailey) Guymer
Pandorea pandorana (Andrews) Steenis
Pararchidendron pruinosum (Benth.) I.C.Nielsen var. *pruinosum*
Parsonsia lanceolata R.Br.
Parsonsia plaesiophylla S.T.Blake
Parsonsia straminea (R.Br.) F.Muell.
Paspalum scrobiculatum L.
Passiflora aurantia G.Forst. var. *aurantia*
Pavetta australiensis Bremek. var. *australiensis*
Pellaea nana (Hook.) Bostock
Pellaea paradoxa (R.Br.) Hook.
Perotis rara R.Br.
Persoonia falcata R.Br.
Petalostigma pubescens Domin
Phyla nodiflora (L.) Greene var. *nodiflora*
Pimelea haematostachya F.Muell.
Pimelea latifolia R.Br. subsp. *latifolia*
Pipturus argenteus (G.Forst.) Wedd.
Pisonia aculeata L.
Pittosporum ferrugineum subsp. *linifolium* (A.Cunn.) L.W.Cayzer, Crisp & I.Telford
Planchonella pohlmaniana (F.Muell.) Pierre ex Dubard
Planchonia careya (F.Muell.) R.Knuth
Platostoma longicorne (F.Muell.) A.J.Paton
Pleurosorus rutifolius (R.Br.) Fee
Pluchea dentex R.Br. ex Benth.
Plumbago zeylanica L.
Pollia macrophylla (R.Br.) Benth.
Polyalthia nitidissima (Dunal) Benth.
Polycarpaea spirostylis F.Muell.
Portulaca bicolor F.Muell.
Portulaca napiformis F.Muell.
Proiphys amboinensis (L.) Herb.
Psychotria daphnoides A.Cunn. ex Hook. var. *daphnoides*
Psydrax odorata f. *australiana* S.T.Reynolds & R.J.F.Hend.
Psydrax saligna S.T.Reynolds & R.J.F.Hend. f. *saligna*
Pteridium revolutum (Blume) Nakai
Pteris ensiformis Burm.f.
Pteris tremula R.Br.
Pterocaulon sphacelatum (Labill.) F.Muell.
Ptilotus nobilis subsp. *semilanatus* (Lindl.) A.R.Bean
Ptychosperma elegans (R.Br.) Blume
Pyrrosia rupestris (R.Br.) Ching
Rhynchosia acuminatissima Miq.
Rhynchosia minima (L.) DC.
Santalum lanceolatum R.Br.
Sarcostemma viminale subsp. *brunonianum* (Wight & Arn.) P.I.Forst.
Sargassopsis decurrens (R.Br. ex Turner) Trevisan
Sargassum carpophyllum J.Agardh
Sargassum flavicans (Mert.) C.Agardh
Sargassum gracile J.Agardh
Sargassum ilicifolium (Turner) C.Agardh
Sargassum microcystum J.Agardh
Sargassum polycystum C.Agardh
Sargassum spinuligerum Sond.
Scaevola spinescens R.Br.
Scaevola taccada (Gaertn.) Roxb.
Schoenoplectus tabernaemontani (C.C.Gmel.) Palla
Secamone elliptica R.Br.
Semecarpus australiensis Engl.
Senna acclinis (F.Muell.) Randell
Senna alata (L.) Roxb.
Senna circinnata (Benth.) Randell
Senna clavigera (Domin) Randell
Senna gaudichaudii (Hook. & Arn.) H.S.Irwin & Barneby
Senna surattensis (Burm.f.) H.S.Irwin & Barneby subsp. *surattensis*
Senna surattensis subsp. *sulphurea* (DC. ex Collad.) Randell
Sersalicia sericea (Aiton) R.Br.
Setaria australiensis (Scribn. & Merr.) Vickery
Solanum dianthophorum Dunal
Solanum erianthum D.Don
Solanum sporadotrichum F.Muell.
Solanum viridifolium Dunal
Sophora tomentosa subsp. *australis* Yakovlev
Sorghum nitidum (Vahl) Pers.
Sorghum plumosum (R.Br.) P.Beauv. var. *plumosum*
Spermacoce brachystema R.Br. ex Benth.
Sterculia quadrifida R.Br.
Sticta myrioloba (Mull.Arg.) D.J.Galloway
Strychnos psilosperma F.Muell.
Stylidium velleioides A.R.Bean
Syringodium isoetifolium (Asch.) Dandy
Syzygium australe (H.L.Wendl. ex Link) B.Hyland
Tabernaemontana orientalis R.Br.
Tabernaemontana pandacaqui Lam.
Tacca leontopetaloides (L.) Kuntze
Tephrosia astragaloides R.Br. ex Benth.
Tephrosia brachyodon Domin
Terminalia melanocarpa F.Muell.
Terminalia muelleri Benth.
Teucrium argutum R.Br.
Thalassia hemprichii (Ehrenb.) Asch.
Thalassodendron ciliatum (Forssk.) Hartog
Thecanthes cornucopiae (Vahl) Wikstr.
Thespesia populneoides (Roxb.) Kostel.
Thuidium cymbifolium (Dozy & Molk.) Dozy & Molk.
Thysanotus banksii R.Br.
Trema orientalis (L.) Blume
Trema tomentosa (Roxb.) H.Hara var. *tomentosa*
Trema tomentosa var. *aspera* (Brongn.) Hewson

Tribulus cistoides L.
Trichodesma zeylanicum var. *latisepalum* F.Muell.
Trichosanthes ovigera Blume
Trophis scandens (Lour.) Hook. & Arn. subsp. *scandens*
Turraea pubescens Hell.
Uraria lagopodioides (L.) Desv. ex DC.
Urena lobata L.
Vachella bidwillii (Benth.) Kodela
Vachellia nilotica (L.) P.J.H.Hunter & Mabb.
Velleia spathulata R.Br.
Vitex melicopea F.Muell.
Vitex trifolia L. var. *trifolia*
Vitex trifolia var. *subtrisecta* (Kuntze) Moldenke
Waltheria indica L.
Wikstroemia indica (L.) C.A.Mey.
Wrightia saligna (R.Br.) F.Muell. ex Benth.
Xerochrysum bracteatum (Vent.) Tzvelev
Ximenia americana L.
Xylocarpus moluccensis (Lam.) M.Roem.
Xyris complanata R.Br.
Zostera capricorni Asch.

Table 22. Species collected by Eugene Fitzalan in the upper Burdekin River area. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Alstonia constricta F.Muell.
Bauhinia acuminata L.
Cynanchum bowmanii S.T.Blake
Dampiera adpressa A.Cunn. ex DC.
Diospyros humilis (R.Br.) F.Muell.
Eremophila mitchellii Benth.
Flindersia dissosperma (F.Muell.) Domin
Grevillea pteridifolia Knight
Hakea lorea (R.Br.) R.Br. subsp. *lorea*
Hibiscus meraukensis Hochr.
Jacksonia ramosissima Benth.
Keraudrenia hookeriana Walp.
Vachellia bidwillii (Benth.) Kodela

Table 23. Species collected by Eugene Fitzalan in the Cairns, Trinity Bay and Port Douglas areas. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Abroma fastuosa R.Br.
Acacia calyculata A.Cunn. ex Benth.
Acacia leptocarpa A.Cunn. ex Benth.
Acacia simsii A.Cunn ex Benth.
Adenostemma lavenia (L.) Kuntze
Adiantum atroviride Bostock
Allocasuarina littoralis (Salisb.) L.A.S.Johnson
Alphitonia whitei Braid
Alstonia muelleriana Domin
Asplenium laserpitiifolium Lam.
Banksia aquilonia (A.S.George) A.S.George
Beilschmiedia obtusifolia (F.Muell. ex Meisn.) F.Muell.
Boea hygroscopica F.Muell.
Bursaria incana Lindl.
Cajanus reticulatus (Aiton) F.Muell.
Callitris macleayana (F.Muell.) F.Muell.
Canavalia papuana Merr. & L.M.Perry
Cephalomanes obscurum (Blume) K.Iwats
Chamaecrista nomame (Siebold) H.Ohashi
Clematis pickeringii A.Gray
Codiaeum variegatum var. *moluccanum* (Decne.) Mull.Arg.
Colysis ampla (F.Muell. ex Benth.) Copel.
Cordyline cannifolia R.Br.
Coronidium elatum (A.Cunn. ex DC.) Paul G.Wilson
Coronidium rupicola (DC.) Paul G.Wilson
Corymbia torelliana (F.Muell.) K.D.Hill & L.A.S.Johnson
Cryptocarya lividula B.Hyland
Cyathea rebeccae (F.Muell.) Domin
Delarbrea michieana (F.Muell.) F.Muell.
Dendrobium semifuscum Lavarack & P.J.Cribb
Deplanchea tetraphylla (R.Br.) F.Muell.
Diplazium dietrichianum (Luerss.) C.Chr.
Diplazium dilatatum Blume
Doodia media R.Br.
Drosera finlaysoniana Wall. ex Arn.
Duboisia myoporoides R.Br.
Elaeagnus triflora Roxb. var. *triflora*
Eucalyptus reducta L.A.S.Johnson & K.D.Hill
Eucalyptus tereticornis Sm.
Gonocarpus acanthocarpus (Brongn.) Orchard
Gossia myrsinocarpa (F.Muell.) N.Snow & Guymer
Gouania australiana F.Muell.
Grevillea glauca Banks & Sol. ex Knight
Grevillea sessilis C.T.White & W.D.Francis
Hakea plurinervia F.Muell. ex Benth.
Harpullia frutescens F.M.Bailey
Helicia australasica F.Muell.
Hypoestes floribunda R.Br. var. *floribunda*
Hypoestes floribunda var. *pubescens* Benth.
Jasminum simplicifolium subsp. *australiense* P.S.Green
Leea indica (Burm.f.) Merr.
Lepistemon urceolatum (R.Br.) F.Muell.
Leucas decemdentata (Willd.) Sm.
Leucopogon leptospermoides R.Br.
Lithomyrtus obtusa (Endl.) N.Snow & Guymer
Lygodium japonicum (Thunb.) Sw.
Macaranga involucrata (Wall.) Baill. ex Mull.Arg.
Mallotus mollissimus (Geiseler) Airy Shaw
Medicosma fareana (F.Muell.) T.G.Hartley
Melastoma malabathricum L. subsp. *malabathricum*
Micromelum minutum (G.Forst.) Wight & Arn.
Mitrasacme oasena Dunlop
Momordica charantia L.
Myrsine variabilis R.Br.
Neosepicaea jucunda (F.Muell.) Steenis
Nephrolepis hirsutula (G.Forst.) C.Presl
Notothixos leiophyllus K.Schum.
Ophioglossum pendulum L.
Orthosiphon aristatus (Blume) Miq.
Oxalis corniculata L.
Palmeria scandens F.Muell.
Pipturus argenteus (G.Forst.) Wedd.
Pitaviaster haplophyllus (F.Muell.) T.G.Hartley
Pittosporum rubiginosum A.Cunn.
Platostoma longicorne (F.Muell.) A.J.Paton
Plectranthus scutellarioides (L.) R.Br.
Polyosma hirsuta C.T.White
Polyscias elegans (C.Moore & F.Muell.) Harms
Polyscias murrayi (F.Muell.) Harms
Pothos longipes Schott

Psilotum complanatum Sw.
Pteridium esculentum (G.Forst.) Cockayne
Pteris pacifica Hieron.
Ptisana oreades (Domin) Murdock
Rhodomyrtus macrocarpa Benth.
Rhynchosia acuminatissima Miq.
Rhysotoechia mortoniana (F.Muell.) Radlk.
Rubus moluccanus var. *trilobus* A.R.Bean
Sarcopteryx martyana (F.Muell.) Radlk.
Schelhammera multiflora R.Br.
Selaginella longipinna Warb.
Sloanea langii F.Muell.
Solanum campanulatum R.Br.
Solanum viridifolium Dunal
Sterculia quadrifida R.Br.
Stylidium graminifolium Sw. ex Willd.
Syzygium cryptophlebium (F.Muell.) Craven & Biffin
Timonius timon (Spreng.) Merr.
Todea barbara (L.) T.Moore
Tricoryne anceps R.Br. subsp. *anceps*
Triumfetta pilosa Roth
Vandasina retusa (Benth.) Rauschert
Vitex trifolia L. var. *trifolia*
Wahlenbergia caryophylloides P.J.Sm.
Xerochrysum bracteatum (Vent.) Tzvelev
Youngia japonica (L.) DC.
Zanthoxylum ovalifolium Wight
Zieria obovata (C.T.White) J.A.Armstr.

Table 24. Species collected by Eugene Fitzalan at Cooktown. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Acrostichum speciosum Willd.
Banksia dentata L.f.
Blepharocarya involucrigera F.Muell.
Bombax ceiba var. leiocarpum A.Robyns
Buchanania arborescens (Blume) Blume
Bursaria tenuifolia F.M.Bailey
Deplanchea tetraphylla (R.Br.) F.Muell.
Dillenia alata (DC.) Martelli
Ixora timorensis Decne.
Lamprolobium fruticosum Benth.
Lomandra banksii (R.Br.) Lauterb.
Lycopodiella cernua (L.) Pic.Serm.
Melaleuca saligna Schauer
Melaleuca viridiflora Sol. ex Gaertn.
Melastoma malabathricum L. subsp. *malabathricum*
Neoroepera banksii Benth.
Nymphaea immutabilis S.W.L.Jacobs
Premna serratifolia L.
Santalum lanceolatum R.Br.
Thalassodendron ciliatum (Forssk.) Hartog
Thryptomene oligandra F.Muell.
Vandasina retusa (Benth.) Rauschert

Table 25. Species collected by Eugene Fitzalan but without the locality indicated. Taxonomy follows that presented in Australian Plant Census (2014) and Australian Plant Name Index (2014).

Acacia riceana Hensl.
Acacia verticillata (L'Her.) Willd. subsp. *verticillata*
Acanthus ilicifolius L.
Adiantum hispidulum Sw.
Aidia racemosa (Cav.) Tirveng.
Alyxia spicata R.Br.
Araucaria cunninghamii Mudie var. *cunninghamii*
Atractocarpus fitzalanii (F.Muell.) Puttock
Bowenia spectabilis Hook. ex Hook.f.
Brachychiton albidus Guymer
Cajanus confertiflorus F.Muell.
Caladenia carnea R.Br.
Calanthe triplicata (Willemet) Ames
Cassia brewsteri (F.Muell.) Benth.
Cepobaculum canaliculatum (R.Br.) M.A.Clem. & D.L.Jones
Clerodendrum inerme (L.) Gaertn.
Corymbia citriodora (Hook.) K.D.Hill & L.A.S.Johnson
Corymborkis veratrifolia (Reinw.) Blume
Crinum flaccidum Herb.
Croton phebalioides F.Muell. ex Mull.Arg.
Cycas media R.Br. subsp. *media*
Cymbidium canaliculatum R.Br.
Cymbidium madidum Lindl.
Dampiera ferruginea R.Br.
Dendrobium discolor Lindl.
Dendrophthoe vitellina (F.Muell.) Tiegh.
Dillwynia cinerascens R.Br.
Dillwynia glaberrima Sm.
Dipodium punctatum (Sm.) R.Br.
Duboisia myoporoides R.Br.
Endiandra compressa C.T.White
Eucalyptus crebra F.Muell.
Eulophia bicallosa (D.Don) P.F.Hunt & Summerh
Huperzia phlegmarioides (Gaudich.) Rothm.
Lepiderema punctulata (F.Muell.) Radlk.
Lepidozamia hopei (W.Hill) Regel
Leptosema oxylobioides F.Muell.
Leucopogon ericoides (Sm.) R.Br.
Lotus australis Andrews
Melastoma malabathricum L. subsp. *malabathricum*
Microsorum membranifolium (R.Br.) Ching
Millettia pinnata (L.) Panigrahi
Morinda citrifolia L.
Nervilia holochila (F.Muell) Schltr.
Pavetta australiensis Bremek. var. *australiensis*
Pavetta granitica F.Muell. ex Bremek.
Phaius australis F.Muell.
Phlegmariurus phlegmaria (L.) T.Sen. & U. Sen.
Plectorrhiza brevilabris (F.Muell.) Dockrill
Plectranthus graveolens R.Br.
Polyalthia nitidissima (Dunal) Benth.
Pseudovanilla foliata (F.Muell.) Garay
Psydrax odorata f. *australiana* S.T Reynolds & R.J.F.Hend.
Ptychosperma elegans (R.Br.) Blume
Senna circinnata (Benth.) Randell
Senna magnifolia (F.Muell.) Randell
Tephrosia purpurea var. *sericea* Benth.
Teratophyllum brightiae (F.Muell.) Holttum
Terminalia porphyrocarpa Benth.
Thelychiton speciosus (Sm.) M.A.Clem. & D.L.Jones
Trachyrhizum agrostophyllum (F.Muell.) Rauschert
Trichodesma zeylanicum (Burm.f.) R.Br. var. *zeylanicum*
Turraea pubescens Hell.
Xerochrysum bracteatum (Vent.) Tzvelev.

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Footnotes

[1] Correspondence: Eugene Fitzalan to Ferdinand Mueller, 1882, 6 March [RB MSS M8, Library, Royal Botanic Gardens Melbourne].

[2] Correspondence: Eugene Fitzalan to the Premier's Department. 1868, May (Queensland State Archives).

[3] *Phaius australis* F.Muell. [MEL1540855]

[4] *Nauclea orientalis* (L.) L. [MEL2051994; MEL2051995]

[5] *Araucaria cunninghamii* Mudie var. *cunninghamii* [MEL0286923]. The Moreton Bay pine is the same taxon, but the southern populations appear to have been regarded as having inferior quality timber.

[6] *Calophyllum inophyllum* L. [BRI AQ0166185; MEL 0075476; MEL 0075484; MEL 0075508; MEL 0075497]

[7] identity not known

[8] *Calophyllum inophyllum* L. [see [6]]

[9] possibly *Dioscoria transversa* R.Br. [no relevant specimens]

[10] *Dendrobium discolor* Lindl. [misapplication of the name *Vanda coerulescens* Griff.] [MEL0624113]

[11] *Dendrobium discolor* Lindl. ['*Dendrobium luridum* W.Hill' was a proposed name]

[12] *Araucaria cunninghamii* Mudie var. *cunninghamii* [see [5]]

[13] possibly *Dendrobium discolor* Lindl. [MEL0624113]

[14] *Mimusops elengi* L. [MEL 2191065; MEL 2192448; MEL 2192451]

[15] possibly *Lotus australis* Andrews [MEL0279509]

[16] possibly *Dendrobium discolor* Lindl. [see[10]]

[17] *Calophyllum inophyllum* L. [see [6]]

[18] identity not known

[19] *Araucaria cunninghamii* Mudie *var. cunninghamii* [see [5]]

[20] possibly *Lotus australis* Andrews [MEL0279509]

[21] possibly *Conospermum taxifolium* C.F.Gaertn. [MEL 1526084]

[22] *Araucaria cunninghamii* Mudie var. *cunninghamii*

[23] *Araucaria columnaris* Hook.

[24] *Erythrina variegata* L. [MEL 2113384]

[25] *Erythrina variegata* L. [*Erythrina fitzalanii* W.Hill was a proposed name]

[26] identity not known

[27] *Ptychosperma elegans* (R.Br.) Blume [MEL 0213375; MEL 2148951; MEL 2148956; MEL 2148960]

[28] *Pandanus tectorius* Parkinson [no known specimen]

[29] *Araucaria cunninghamii* Mudie var. *cunninghamii*

[30] *Brachychiton* spp

[31] *Acacia* spp

[32] *Erythrina variegata* L. [see [24 & 25]]

[33] possibly *Hibiscus heterophyllus* Vent subsp. *heterophyllus* [MEL0018725] or *Hibiscus meraukensis* Hochr. [MEL0018686]

[34] *Eucalyptus* and *Corymbia* spp

[35] possibly *Corymbia tessellaris* (F.Muell.) K.D.Hill & L.A.S.Johnson

[36] *Melaleuca* spp

[37] *Ficus* sp.

[38] *Ochrosia elliptica* Labill. [MEL 1587754]

[39] Gutta percha was the name given to a type of latex, usually from species of *Palaquium* that was used extensively for insulation and in dentistry (Prakash *et al.* 2005).

[40] *Mackinlaya macrosciadea* (F.Muell.) F.Muell. [MEL 0247913]

[41] possibly *Claoxylon angustifolium* Mull.Arg. [MEL 0707740]

[42] possibly *Sophora tomentosa* L. [MEL 0019113; MEL 0019086; MEL 0019088]

[43] *Xerochrysum bracteatum* (Vent.) Tzvelev [MEL0061207]

[44] possibly *Eragrostis* sp. [MEL2134015]

[45] identity not known

[46] possibly *Euphorbia hypericifolia* L. [no relevant specimens]

[47] possibly *Hibiscus sturtii* Hook. [MEL2223546].

[48] possibly *Maclura cochinchinensis* (Lour.) Corner [no relevant specimens]

[49] possibly *Ficus opposita* Miq. [MEL0239354]

[50] identity not known

[51] possibly *Archirhodomyrtus beckleri* (F.Muell.) A.J.Scott [no relevant specimens]

[52] *Cochlospermum gillivraei* Benth. [MEL 0081439]

[53] *Cycas media* R.Br. [MEL 0269944; MEL 0269949]

[54] *Cochlospermum gillivraei* Benth. [see [52]]

[55] *Cycas media* R.Br. [see [53]]

[56] *Larsenaikia ochreata* (F.Muell.) Tirveng. [MEL 0598351; MEL 0598353; MEL 0713513]

[57] possibly *Atractocarpus fitzalanii* (F.Muell.) Puttock [MEL 0598569]

[58] possibly *Hibiscus heterophyllus* Vent subsp. *heterophyllus* [MEL0018725]

[59] identity not known

[60] possibly *Millettia pinnata* L. [MEL2093468]

[61] identity not known

[62] possibly *Toona ciliata* M.Roem. or *Paraserianthes toona* (F.M.Bailey) I.C.Nelson [no relevant collections]

[63] *Bursaria incana* Lindl. [MEL0066044]

[64] *Ficus* sp.

[65] *Araucaria cunninghamii* Mudie var. *cunninghamii*

[66] possibly *Alstonia scholaris* (L.) R.Br. [no relevant specimens]

[67] possibly *Canavalia rosea* (Sw.) DC. [no relevant specimens]

[68] possibly *Eucalyptus crebra* F.Muell. [MEL 0703988] or *E. tereticornis* Sm. [MEL 0707234]

[69] possibly *Memecylon pauciflorum* Blume [now classified in the Memecylaceae] [no relevant specimens]

[70] *Cajanus confertiflorus* F.Muell. [MEL 0091588; MEL 0061471–2]

[71] possibly *Sophora tomentosa* L. [no relevant specimens]

[72] *Araucaria cunninghamii* Mudie var. *cunninghamii* [MEL 0286923]

[73] *Dendrophthoe vitellina* (F.Muell.) Tiegh. [MEL 0591630; MEL 0591630; MEL 2237734]

[74] *Hibiscus tiliaceus* L. [MEL 2223595]

[75] identity not known

[76] identity not known

[77] *Cochlospermum gillivraei* Benth. [MEL0081439]

[78] *Hoya australis* R.Br. ex J.Traill var. *australis* [MEL 0073610]

[79] *Cycas media* R.Br. [MEL2136950, MEL2136951]

[80] identity not known

[81] possibly *Denhamia disperma* (F.Muell.) M.P.Simmons [no relevant specimens]

[82] possibly *Atractocarpus fitzalanii* (F.Muell.) Puttock

[83] possibly *Canarium australianum* F.Muell. [MEL 0532416; MEL 2290901]

[84] identity not known

[85] possibly *Aglaia elaeagnoidea* (A.Juss.) Benth. [no relevant specimens]

[86] identity not known

[87] possibly one of a few *Corymbia* spp or *Eucalyptus tereticornis* Sm. [MEL 0707234]

[88] possibly *Phaleria octandra* (L.) Baill. [no relevant specimens]

[89] identity not known

[90] possibly *Clerodendrum floribundum* R.Br. [MEL 0098165] or *Clerodendrum inerme* (L.) Gaertn. [MEL0098258, MEL0098286]

[91] possibly *Crotalaria laburnifolia* L. [no relevant specimens]

[92] possibly *Abutilon* or *Hibiscus* sp.

[93] identity not known

[94] possibly *Hibiscus heterophyllus* Vent. [no relevant specimens]

[95] *Sterculia quadrifida* R.Br. [MEL 2226804; MEL 2226815]

[96] *Pseudanthus pimeleoides* Sieber ex Spreng. [no relevant specimens]

[97] *Limonium solanderi* Lincz. [MEL 0044384; MEL 0044385]

[98] *Neptunia major* (Benth.) Windler [MEL 0596305]

[99] possibly *Dioscoria* sp.

[100] *Pleiogynium timorense* DC.) Leenh. [no relevant specimens]

[101] *Guettarda speciosa* L. [MEL2266812; MEL 2266057]

[102] *Ehretia acuminata* R.Br. [MEL 0657360]

[103] *Millettia pinnata* (L.) Panigrahi [MEL 2093275; MEL 2093278; MEL 2093280; MEL 2093281; MEL 2093282; MEL 2093476; MEL 2093478]

[104] identity not known

[105] *Sterculia quadrifida* R.Br. [MEL2226802]

[106] possibly *Morinda citrifolia* L. [MEL 0010114]

[107] possibly *Eucalyptus platyphylla* F.Muell. [MEL 0703561] or *Eucalyptus tereticornis* Sm. [MEL 0707234]

[108] identity not known

[109] *Alyxia spicata* R.Br. [MEL 0223097]

[110] *Diospyros geminata* (R.Br.) F.Muell. [MEL2223158; MEL 2232822]

[111] *Psydrax odorata* (G.Forst.) A.C.Sm. & S.P.Darwin [MEL 1538229]

[112] *Trophis scandens* (Lour.) Hook. & Arn. [MEL 2210549]

[113] *Melia azederach* L. [MEL 0119044–6; MEL 0119054]

[114] *Dendrobium discolor* Lindl.

[115] possibly *Eulalia aurea* (Bory) Kunth [no relevant specimens]

[116] identity not known

[117] identity not known

[118] identity not known

[119] identity not known

[120] identity not known

[121] *Pisonia aculeata* L. [MEL 2218020]

[122] *Derris trifoliata* Lour. [MEL 1517640]

[123] *Guettarda speciosa* L. [see [101]]

[124] *Rockhampton Bulletin*. Telegraphic messages. Saturday, 13 August 1870, p. 2.

[125] *The Mail.* Earldom of Egmont Australian-born claimant. Saturday, 18 May 1929, p. 3.

[126] Samphire open-forblands on saltpans occur in many of the bay heads in this area.

[127] *Eucalyptus* open forest and woodland communities occur in this area.

[128] Complex notophyll vineforest and semi-evergreen vine thickets occur in this area.

[129] *Araucaria cunninghamii* Mudie var. *cunninghamii* [no relevant specimens]

[130] *Lysiphyllum hookeri* (F.Muell.) Pedley [MEL 0069755]

[131] possibly *Themeda triandra* Forssk. [no relevant specimens]

[132] *Cassia* sp. (Paluma Range)

[133] *Laburnum anagyroides* Medik.

[134] possibly *Argyrodendron polyandrum* L.S.Sm. [BRI AQ0081161] or *Argyrodendron trifoliolatum* F.Muell. [MEL 2223875; MEL 2223876; MEL 2223878]

[135] *Ptychosperma elegans* (R.Br.) Blume [MEL 0213375; MEL 2148951; MEL 2148956]

[136] *Archontophoenix alexandrae* (F.Muell.) H.Wendl. & Drude [no relevant specimens]

[137] *Dendrocnide moroides* (Wedd.) Chew [no relevant specimens]

[138] *Helix macleayi* Cox, 1864

[139] *Xanthomelon pachystylum* Pfeiffer, 1845

[140] *Gloreugenia coxeni* Cox, 1871

[141] *Sphaerospira oconnellensis* Cox, 1871

[142] *Pupina meridionalis* Pfeiffer, 1864

[143] *Sphaerospira coxi* Crosse, 1866

[144] *Ptychosperma elegans* (R.Br.) Blume [no relevant specimens]

[145] *Schefflera actinophylla* (Endl.) Harms [no relevant specimens]

[146] possibly *Entada phaseoloides* (L.) Merr. or *Entada rheedii* Spreng.; the so-called match-box bean [no relevant specimens]

[147] *Cassia* sp. (Paluma Range) [no relevant specimens]

[148] *Ptychosperma elegans* (R.Br.) Blume [no relevant specimens]

[149] *Ficus watkinsiana* F.M.Bailey [MEL 0239415]

[150] *Brachychiton acerifolius* (A.Cunn. ex G.Don) F.Muell. [no relevant specimens]

[151] *Thelychiton speciosus* (Sm.) M.A.Clem. & D.L.Jones [no relevant specimens]

[152] Roma Peak is an isolated rocky massif to about 610 m elevation, 40 km to the west of Mount Dryander.

[153] *Adiantum* sp; probably not this genus as it is terrestrial rather than epiphytic.

[154] *Asplenium* sp.

[155] *Pteris* sp. [possibly *Doryopteris concolor* (Langsd. & Fisch.) Kuhn [MEL 1558921]; although it is a terrestrial species rather than epiphytic.

[156] *Ophioglossum* sp.

[157] *Fastosarion superba* Cox, 1871

[158] *Gloreugenia coxeni* Cox, 1871

[159] *Sphaerospira informis* Mousson, 1869

[160] *Pedinogyra hayii* Griffith & Pidgeon, 1833

[161] *Bentosites yulei* Forbes, 1851

[162] *Helix kilneri* [a name of no standing]

[163] John Graham MacDonald (b. 5 September 1834; d. 29 May 1918) was one of the pioneer settlers of Bowen, arriving in 1861 as a member of Dalrymple's overland party. He acquired extensive land holdings throughout north Queensland, but was to later relinquish them because of financial problems. In 1872 he became Gold Commissioner at Gilberton, a now-abandoned township on the upper Gilbert River, and a Police Magistrate at Charters Towers (Pike 1996; Hooper 2002).

[164] Semi-deciduous notophyll/mesophyll vine forest fringing watercourses is an Endangered regional ecosystem.

[165] possibly *Pandanus cookii* Martelli [no relevant specimens]

[166] *Cymbidium madidum* Lindl. [no relevant specimens]

[167] *Platycerium* sp. [correctly as Elk-horn ferns, as there are no Stag-horn ferns in this area]

[168] possibly *Asplenium australasicum* (J.Sm.) Hook.

[169] The vegetation here is low microphyll vine forest to semi-evergreen vine thick with *Acacia fasciculifera* F.Muell. ex Benth. [no relevant specimens]

[170] *Helix murina* Pfeiffer, 1866

[171] *Araucaria cunninghamii* Mudie var. *cunninghamii*

[172] possibly *Argyrodendron polyandrum* L.S.Sm. [BRI AQ0081161] or *Argyrodendron trifoliolatum* F.Muell. [MEL 2223875; MEL 2223876; MEL 2223878]

[173] *Ficus* sp.

[174] *Schefflera actinophylla* (Endl.) Harms [no relevant specimens]

[175] *Brachychiton acerifolius* (A.Cunn. ex G.Don) F.Muell. [no relevant specimens]

[176] *Fastosarion superba* Cox, 1871

[177] *Pedinogyra hayii* Griffith & Pidgeon, 1833

[178] *Sphaerospira informis* Mousson, 1869

[179] *Coelocion australis* Forbes, 1851

[180] *Calamus australis* Mart. [no relevant specimens]

[181] *Vittaria elongata* Sw. [MEL2155631]

[182] *Arthropteris tenella* (G.Forst.) J.Sm. ex Hook.f. [MEL0239184]

[183] possibly *Polypodium lanceola* Mett. or *Belvisia mucronata* (Fee) Copel. [no relevant specimens]

[184] *Pteris ensiformis* Burm.f. [no relevant specimens]

[185] *Davallia denticulata* (Burm.f.) Mett. ex Kuhn [no relevant specimens]

[186] *Asplenium polypodioides* (Blume) Mett. This is possibly an identification provided by Mueller, but it is a *nom. illeg.*

[187] *Cepobaculum canaliculatum* (R.Br.) M.A.Clem. & D.L.Jones [no relevant specimens]

[188] identity not known: *Cryptostylis ovata* R.Br. is endemic to Western Australia.

[189] possibly *Cyathea rebeccae* (F.Muell.) Domin as *Cyathea leichhardtiana* (F.Muell.) Copel. is not recorded for Mount Dryander. [MEL2152299]

[190] *Araucaria cunninghamii* Mudie var. *cunninghamii*

[191] possibly *Archontophoenix alexandrae* (F.Muell.) H.Wendl. & Drude, not *Ptychosperma elegans* (R.Br.) Blume, as the habitat is not correct for the latter species.

[192] Notophyll mossy evergreen vine forest. The Rare *Ristantia waterhousei* Peter G.Wilson & B.Hyland occurs here, and epiphytic species are common at this elevation.

[193] *Brussels* carpet was a machine made floor covering with the loops of the pile uncut, and *Turkey* produced the highest quality crafted carpets during this period.

[194] *Berlin wool* is a fine worsted yarn used for knitting and embroidery.

[195] *Ficus copiosa* Steud. [no relevant specimens]

[196] Correspondence: Ferdinand Mueller to Joseph Hooker. 1869, 4 December (Royal Botanic Gardens Melbourne).

[197] possibly *Cassia brewsteri* (F.Muell.) Benth. [MEL0253197]

[198] Correspondence: Eugene Fitzalan to Ferdinand Mueller. 1871, 20 April (Royal Botanic Gardens Melbourne).

[199] *Neisosperma kilneri* (F.Muell.) Fosberg & Sachet [MEL1587729]

[200] *Sydney Morning Herald*. Port Denison Items. Wednesday, 10 January 1866, p. 5.

[201] Correspondence: Ferdinand Mueller to William Hooker. 1863, 25 September (Royal Botanic Gardens Kew. Directors' letters, vol. LXXV, Australian and Pacific letters 1859–65, letter no. 175).

[202] Correspondence: Ferdinand Mueller to August Petermann. 1864, 26 August (Home *et al.* 2002; Royal Botanic Gardens Melbourne).

[203] '*Musa australiensis*'. *Nomen dubium*. This was a name used in correspondence by Mueller. Correctly *Musa banksia* F.Muell. [BRIAQ0023362, MEL0621530 – 0621537]

[204] *Araucaria bidwillii* Hook.

[205] Augustus William Simpson, a collector of beetles, was in residence at Salisbury Station 1870 –1873. *Rockhampton Bulletin*. Salisbury Station. Friday, 21 February 1873.

[206] *Araucaria cunninghamii* Mudie var. *cunninghamii* [MEL0255286]

[207] *Helix* L. is a genus of land snails, Class Gastropoda.

[208] Notophyll vine forests occur on the eastern slopes and valleys, but otherwise the dominant vegetation is wet sclerophyll and tall open forests, and with Araucarian vine forest on the western slopes.

[209] possibly *Arundinella nepalensis* Trin., *Chionachne cyathopoda* (F.Muell.) F.Muell. ex Benth., *Imperata cylindrica* (L.) P.Beauv., *Ottochloa* spp and *Themeda* spp [no relevant specimens]

[210] *Eucalyptus crebra* F.Muell. [MEL1608355, MEL0703989]

[211] possibly *Eucalyptus resinifera* Sm. [no relevant specimens]

[212] *Allocasuarina torulosa* (Aiton) L.A.S.Johnson [MEL0538075]

[213] *Archontophoenix alexandrae* (F.Muell.) H.Wendl. & Drude. *Archontophoenix cunninghamiana* (H.Wendl.) H.Wendl. & Drude occurs on the high slopes and ridges (*pers. comm.* Andrew Ford; *pers. obs.* J.L. Dowe).

[214] Land snails collected by Rainbird from Mount Elliot have not been located.

[215] *Archontophoenix alexandrae* (F.Muell.) H.Wendl. & Drude and *Livistona decora* (W.Bull.) Dowe are dominant species in riparian forests on the eastern flanks of Mount Elliot.

[216] *Port Denison Times*. A Trip to Whitsunday. Saturday, 18 July 1874, pp 2, 3.

[217] possibly *Plectranthus diversus* S.T.Blake or *Plectranthus parviflorus* Willd.
[no relevant collections]

[218] *Ipomoea macrantha* Roem. & Schult. [no relevant collections]

[219] Notophyll vine forest +/- *Araucaria cunninghamii* extend to the beach over most of the island.

[220] *Ptychosperma elegans* (R.Br.) Blume forms extensive populations here.

[221] *Entada rheedii* Spreng. [MEL0595411]

[222] Blue bean is possibly *Rhynchosia acuminatissima* Miq. [no relevant collections]

[223] Red bean is possibly *Abrus precatorius* L. [no relevant collections]

[224] Various formations of mesophyll rainforests were extensive in the area.

[225] Red cedar, *Toona ciliata* M.Roem., was the most sought-after timber in the area.

[226] *The Queenslander*. The Cedar Country. Saturday, 7 November 1874, p. 6.

[227] *The Queenslander*. Forest conservancy. Saturday, 29 December 1877, p. 16.

[228] *Rockhampton Bulletin*. Northern News. Saturday, 4 September, 1875, pp 2, 3.

[229] *Sydney Morning Herald*. Botanical. Tuesday, 1 August 1876, pp 4, 5.

[230] Correspondence: Ferdinand Mueller to Edward Ramsay. 1876, 28 January (ML MSS.562, Letters to E. P. Ramsay 1862–91, Mitchell Library, State Library of New South Wales, Sydney).

[231] Mueller named three *Musa* species based on Fitzalan's collections: *Musa banksii* F.Muell. (collected from Mount Elliot), *Musa fitzalanii* F.Muell. and *Musa hillii* F.Muell., both collected from the Daintree area. For discussion about species identities see Simmonds (1956).

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Aspects of the distribution and ecology of the rare shrub *Prostanthera tallowa* (Lamiaceae), an endemic of the lower Shoalhaven River valley, South Coast, NSW

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Abstract: The results of a field survey of *Prostanthera tallowa* (family Lamiaceae), a rare and only recently described shrub from the lower Shoalhaven River valley, on the NSW South Coast, are described. The extent and size of populations in the vicinity of the type locality at Tallowa Dam are greatly expanded and several new and distant populations are described. Information is provided on all known populations and their habitat. The species is regarded as adequately reserved, as almost all known populations occur in protected areas though the actual area of occupancy is small. The species recruits after fire with most sites having been burnt about 10 years ago; the total known population size is currently over 3,300 plants.

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Introduction

Although recognised as distinct since the 1980s (the type specimen was collected in 1988), the shrub *Prostanthera tallowa* (family Lamiaceae) was only formally described by Conn and Wilson in 2012, despite the general area of occurrence being readily accessible by motor vehicle for a long time. The taxon was previously referred to as *Prostanthera* sp. 'E' in *Plants of New South Wales* (Jacobs & Pickard 1981), *Flora of NSW, Volume 3* (Conn, in Harden 1992) and *Flora of the Sydney Region* (Pellow *et al*. 2009). It was not included in a list of rare, un-named species of *Prostanthera* in Briggs and Leigh (1996).

At the time of its formal description, and indeed until this study, the species was known only from one small area near Tallowa Dam on the Shoalhaven River, west of Nowra, on the southern edge of the Central Coast Botanical Subdivision, where Conn and Wilson (2012) estimated the number of plants (population 1c in this study) to be about 50 plants. This paper describes the results of recent searches for additional sites and updates the investigations in Mills (2014).

The name *Tallowa* appears on the current Burrier and Bundanoon 1:25 000 maps in two places, namely Tallowa Gully, a significant tributary of Bundanoon Creek, and Tallowa Dam. The parish of Tallowal [*sic*] is on the southern side of the Shoalhaven Gorge. The map of New South Wales prepared by surveyor Thomas Mitchell in 1834 shows only the eastern end of what is now known as Tallowa Gully, which is un-named on the map, and places the name Tallowa where Badgerys Spur meets the Shoalhaven River, i.e. at Badgerys Crossing Place. The headwaters of Tallowa Gully are not far north of the Tallowa location of Mitchell. The diary of Charles Throsby contains a reference to Tallawa [*sic*] at Barron Flat at the junction of the Shoalhaven and Kangaroo Rivers, i.e. the site of today's Tallowa Dam. The word is apparently of Aboriginal origin. Thus, the same name is identified at two locations in the Shoalhaven Gorge, perhaps suggesting that the name was given by the Aboriginal people to the Shoalhaven Gorge between the two points mentioned above.

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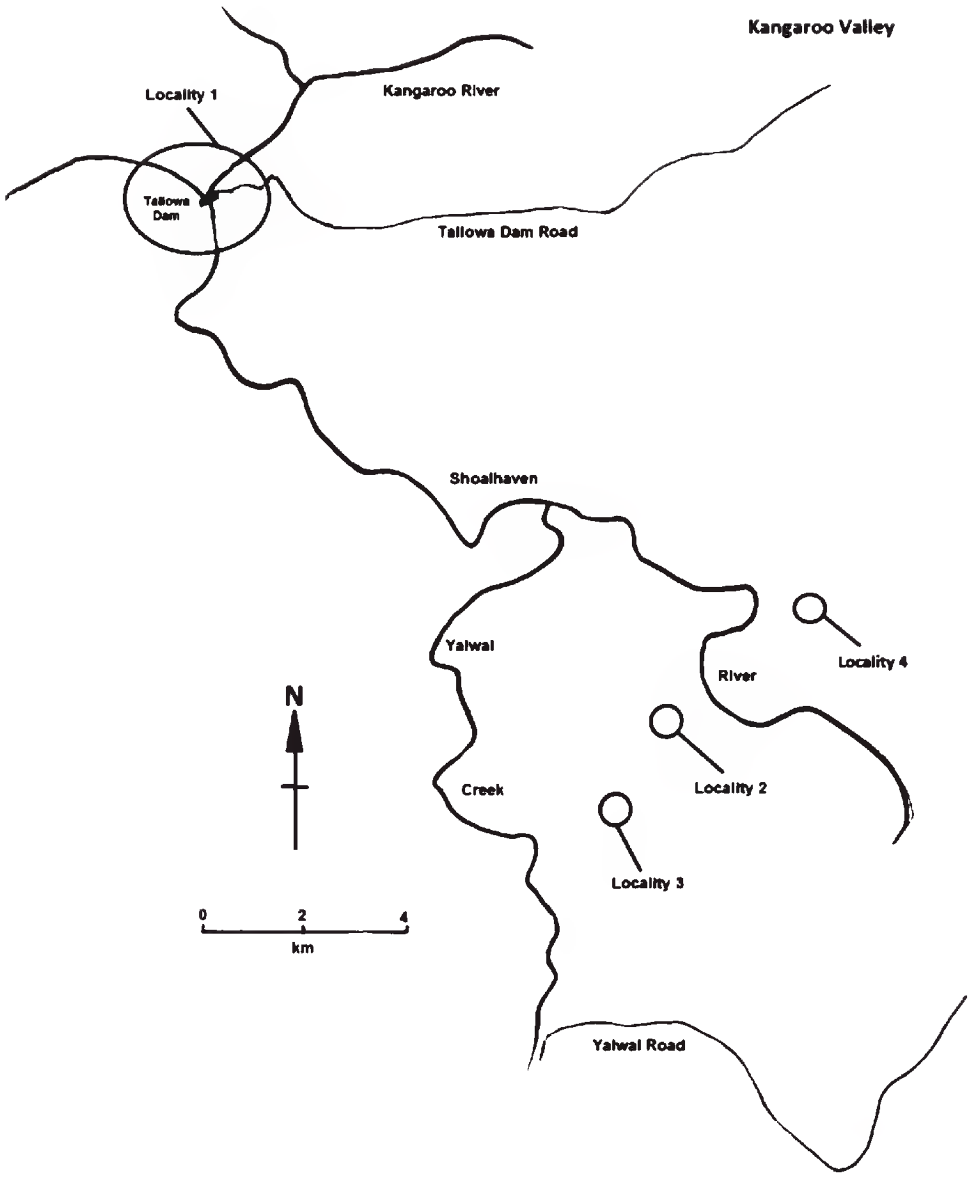

Fig. 1. General location of known populations of *Prostanthera tallowa* in Nowra area.

Methods

Field surveys in 2013 and 2014 investigated the extent, population size and general ecology of *Prostanthera tallowa*. Searches initially focused on the type locality at Tallowa Dam, with subsequent searches extending out in all directions. The fortuitous discovery of a population 14 km to the southeast led to a search of Morton State Conservation Area (Mills 2013). It soon became clear that the species is associated with clifflines, and these areas became the primary focus of searches.

For each discrete population, information was recorded on geology, habitat, associated plant community and associated plant species, the condition of the plants of *Prostanthera tallowa*, and general information on the site. The number of plants in each population was counted as the site was searched. GPS recordings were taken at the limits of each population. The sites were also marked onto a topographic map in the field and various digital photographs were taken. At two populations, all plants counted were allocated to a height class, as an approximate surrogate for plant age.

Results

Distribution

Prostanthera tallowa was found in four distinct, well-separated localities, three of which contain several separate populations in relatively close proximity, with no plants

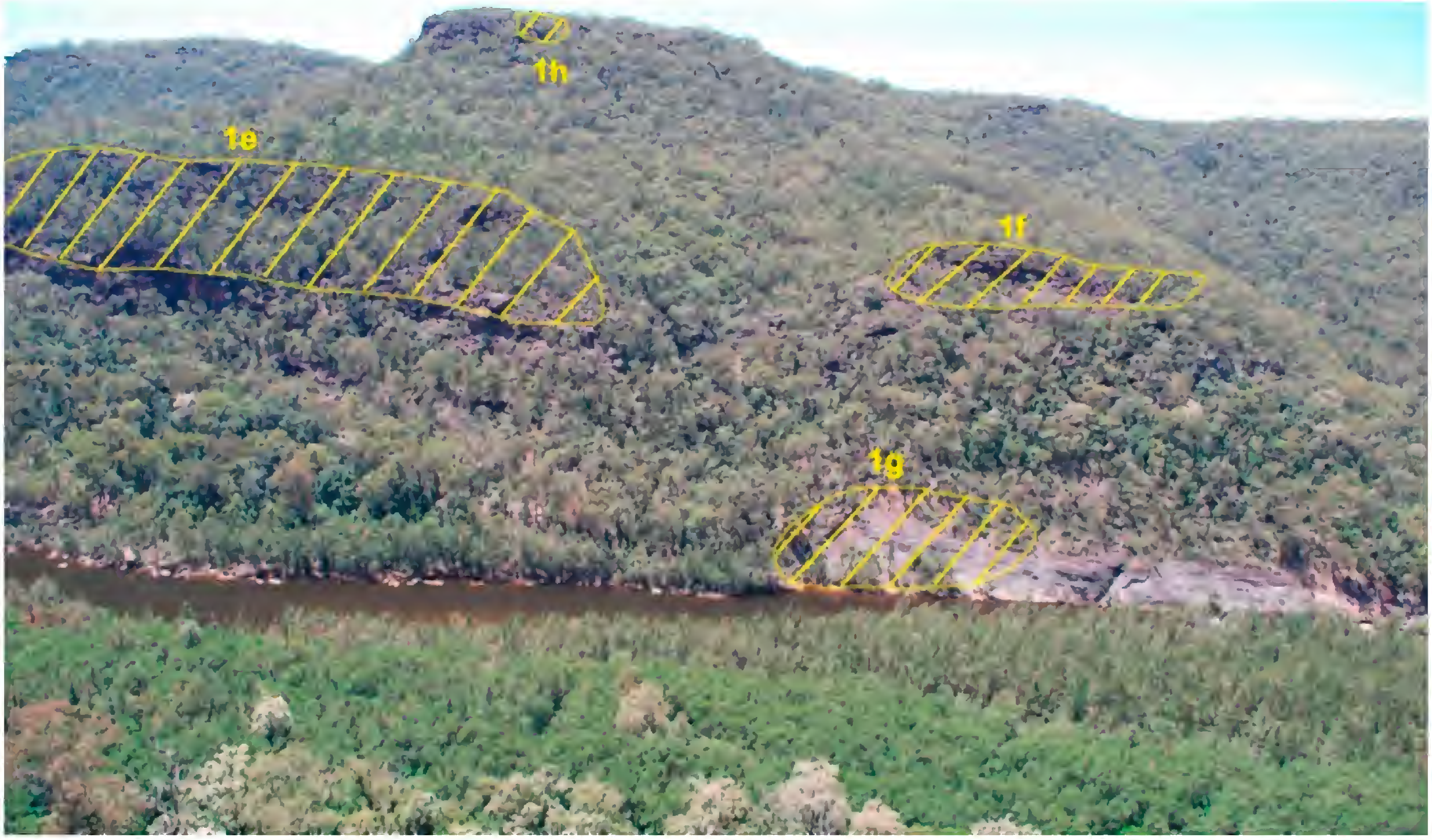

Fig. 2. Habitat of *Prostanthera tallowa* populations near Tallowa Dam. Photograph looking north across the river from the escarpment at population 1j. Geology: 1h - Nowra Sandstone; 1e and 1f - Snapper Point Formation; 1g - Tallong Conglomerate.

Table 1. Summary of known populations of Prostanthera tallowa

Site No.	Locality/ Population/GPS	No.of plants	Habitat/ Vegetation
1	Tallowa Dam		
1a	Tallowa Dam Road (upper east) Morton National Park 0255220 61499349 to 0255151 6149427	25	road cutting (low rock face) scattered plants
1b	Tallowa Dam Road (upper west) Morton National Park 02551134 6149514 to 0255137 6149437	184	escarpment cliffs/ disturbed roadside open woodland
1c	Tallowa Dam Road (lower) Morton National Park 0254921 6149313 to 0254778 6149226	139	escarpment cliffs open woodland/shrubland
1d	Tallowa Dam escarpment (east) Morton National Park 0254646 6148706 to 0254620 6149068	357	escarpment cliffs open woodland/ shrubland
1e	Barron Flat escarpment (north) Morton National Park 0254703 6148703 to 0254543 6148003	841	escarpment cliffs open woodland/mallee/ shrubland
1f	Barron Flat escarpment (south) Morton National Park 0254604 6147756 to 0254573 6147934	121	escarpment cliffs open woodland
1g	River side cliff Morton National Park 0254423 6147937	37	conglomerate cliff scattered shrubs/small trees
1h	Tallowa Dam lookout Morton National Park 0255148 6147649	2	sandstone cliff edge woodland
1i	Tallowa Dam west Morton National Park 0253458 6148708 to 0253503 6148585	166	sandstone cliff edge woodland/shrubland
1j	Tallowa Dam southwest Morton National Park 0253534 6148453 to 0253792 6148148	362	sandstone cliff edge woodland/shrubland
1k	Tallowa Dam south Morton National Park 0253926 6147977 to 0254008 6147833	21	sandstone cliff edge woodland/shrubland
1l	North of Purri Plateau Morton National Park 0253400 6148450	240	sandstone cliff edge woodland/shrubland
1m	East of Purri Plateau Morton National Park 0253880 6147708	26	rocky gully side open forest/ tall shrubland
2	Grassy Gully[1] Unnamed creek Morton State Conservation Area 0263487 6139226)	324+	small gorge/cliff top dry rainforest
3	Durkin Spur escarpment		
3a	Escarpment (north) Morton State Conservation Area 0262669 6137655 to 0262558 6137449	391	exposed escarpment edge open woodland /heathland
3b	Escarpment (west) Morton State Conservation Area 0262288 6137377	12	exposed escarpment edge open forest/shrubland
3c	Escarpment (south) Morton State Conservation Area 0262562 6137299	10	exposed escarpment edge open forest/shrubland
4	Bugong escarpment Illaroo Lookout 0265900 6141500	50+	exposed escarpment edge open forest/shrubland
Total counted population		3308+	

1. The location is in a small un-named gully east of Grassy Gully itself, which empties directly into the Shoalhaven River to the north.

Table 2. Characteristics of sites of the known localities

Site	Geology	Altitude	Aspect	Last fire[1]	Plants
1a-1f	Snapper Point Formation	100-210 m	southwest to northwest	Jan. 2003	1667
1g	Tallong Conglomerate	50 m	south	Jan. 2003	37
1h	Nowra Sandstone	310 m	south	Jan. 2003	2
1i-1m	Snapper Point Formation	200-250 m	north to west	Jan. 2003	815
2	Grassy Gully Rhyolite	75 m	northeast	Jan. 2003	324+
a-3c	Nowra Sandstone	330-360 m	west to north	Jan. 2003	413
4	Nowra Sandstone	248 m	south	unknown	50+

1. It is unlikely that all of the area burnt, as rocks and escarpments result in a mosaic of burning.

Table 3. Distribution of plant heights in two populations

Population	<20cm	20-50cm	50-100cm	100-200cm	>200cm	All
1c	4 (3%)	4 (3%)	13 (9%)	37 (27%)	81 (58%)	139
3a	8 (2%)	31 (8%)	87 (22%)	217 (55%)	48 (12%)	391

in the intervening areas (Figure 1). The localities occur in Morton National Park (including the Sydney Catchment Authority Special Area around Tallowa Dam), in Morton State Conservation Area, and at one site just outside Bugong National Park; these sites are up to 14 km distant from each other.

The four separate localities and their constituent populations are summarised in Table 1. The Tallowa Dam locality (1) is within Morton National Park and the in-holding that is the Sydney Catchment Authority Special Area around Tallowa Dam. Locality 3 is about 14 km to the southwest of locality 1, while locality 2 is about 1.8 km to the north-north-east of locality 3. The Grassy Gully (2) and Durkin Spur (3) localities are within Morton State Conservation Area, which adjoins Morton National Park to the west. Location 4 is on the escarpment at Illaroo Lookout, just south of the boundary of Bugong National Park and on the northern side of the Shoalhaven River, about 3.7 km northeast of the closest population in Morton SCA.

The total area occupied by the known populations is quite small, in the order of a few hectares of habitat, based on the limits of the populations determined through the field survey. There are hundreds of kilometres of escarpment and rock outcrop in the district that could support this species, so further populations are almost certain to occur in the wider area, particularly along the Shoalhaven River gorge between the two known locations of Bugong and Tallowa Dam.

Field surveys during 2013–2014 greatly extended the known range of the species from the type locality next to Tallowa Dam Road, as well as significantly increasing the number of plants known to exist. Searches along the escarpments to the north, south and west of the dam found the species to be common on the exposed edges of most escarpments. The typical habitat of the populations around Tallowa Dam is shown on Figure 2; the yellow hatching showing the distribution of the populations indicated.

Habitat

The consistent feature of the habitat of all known *Prostanthera tallowa* populations is their occurrence on substantial rock outcrops, primarily on the exposed edges of escarpment cliffs. The altitude range of the populations is from 50 to 360 m. Four geological substrates are involved (Table 2); localities 1, 3 and 4 are on similar, coarse-grained sandstone of Permian age, namely the Snapper Point Formation and the Nowra Sandstone. A small population (1g) occurs on the Tallong Conglomerate, which underlies the Snapper Point Formation and crops out in the gorge near the Shoalhaven River. Populations 1h and 4 occur on the Nowra Sandstone, while locality 2 is growing on the Grassy Gully Rhyolite of Devonian age, which underlies the Permian sediments. Locality 2 is in a valley on the cliff edge of a small rocky gorge.

Prostanthera tallowa does not seem to grow in dense heathland or forest, but occurs in sparsely treed areas with open heathland and rock very visible on the surface. On the escarpment sites the species grows on the cliff face and on the exposed edge of the escarpment, usually extending no more than 10 m behind the edge unless the vegetation is very open. The type of vegetation associated with each population ranges from open heathland to dry rainforest; see Table 1. The dry rainforest at locality 2 is dominated by *Backhousia myrtifolia*, which is typical of the deeply incised gullies in the general area. Much of the area around the Grassy Gully site is exposed rhyolite rock.

The plant species associated with the known populations are characteristic of the Sydney Basin sandstones. Typical species are those that are often associated with rock outcrops and exposed escarpment cliffs, such as the trees *Eucalyptus punctata* and *Eucalyptus agglomerata,* the mallee *Corymbia eximia* and the shrubs *Kunzea ambigua, Dodonaea truncatiales* and *Dillwynia ramosissima*. The rare shrub *Acacia subtilinervis* is also often associated with the stands of *Prostanthera tallowa* at the Tallowa Dam sites, as is the regionally rare *Olearia ramosissima.*

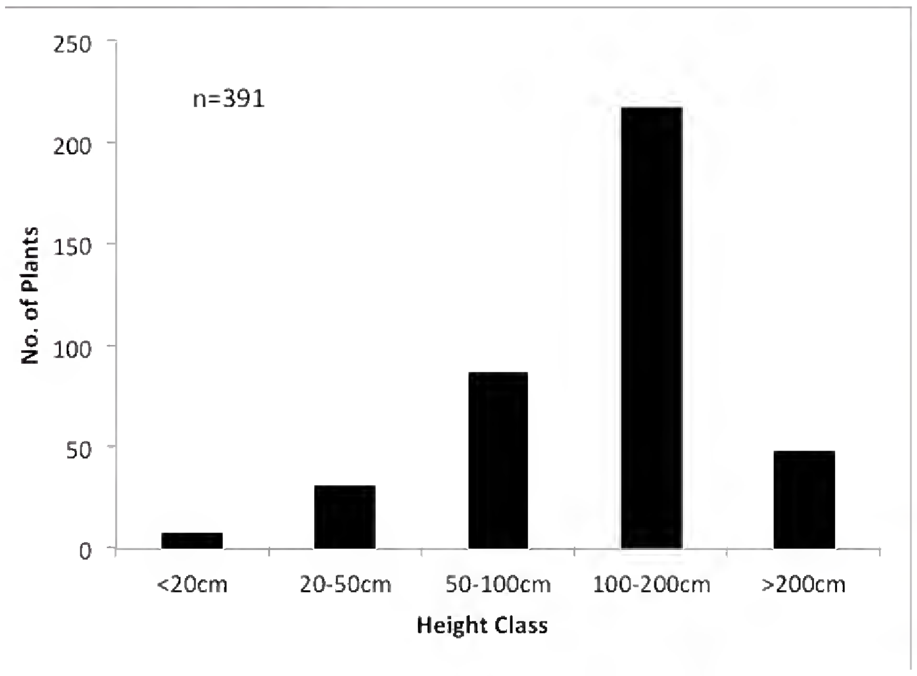

Fig. 3a. Distribution of plant heights in population 3a.

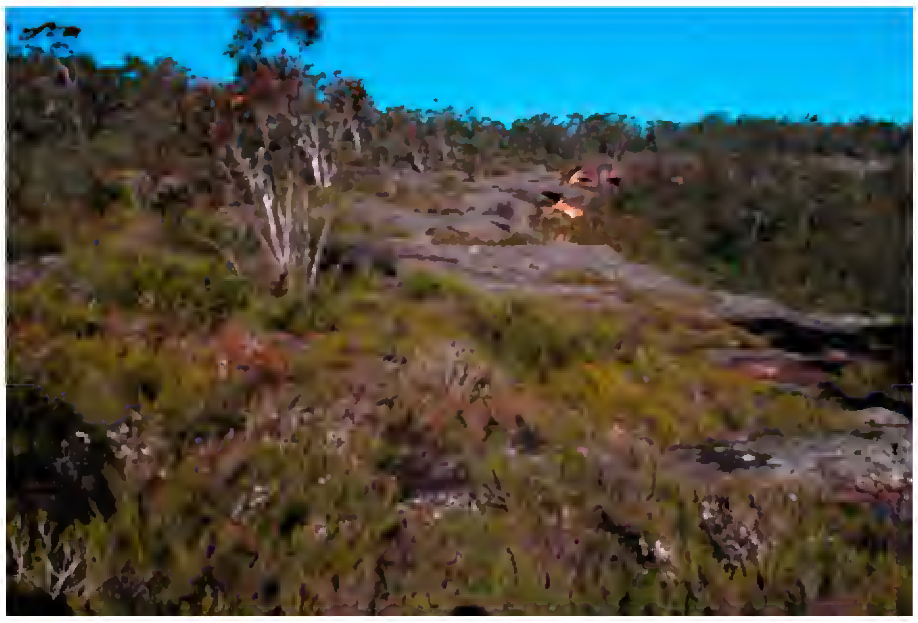

Fig. 5. Habitat of population 3a; escarpment is to the right.

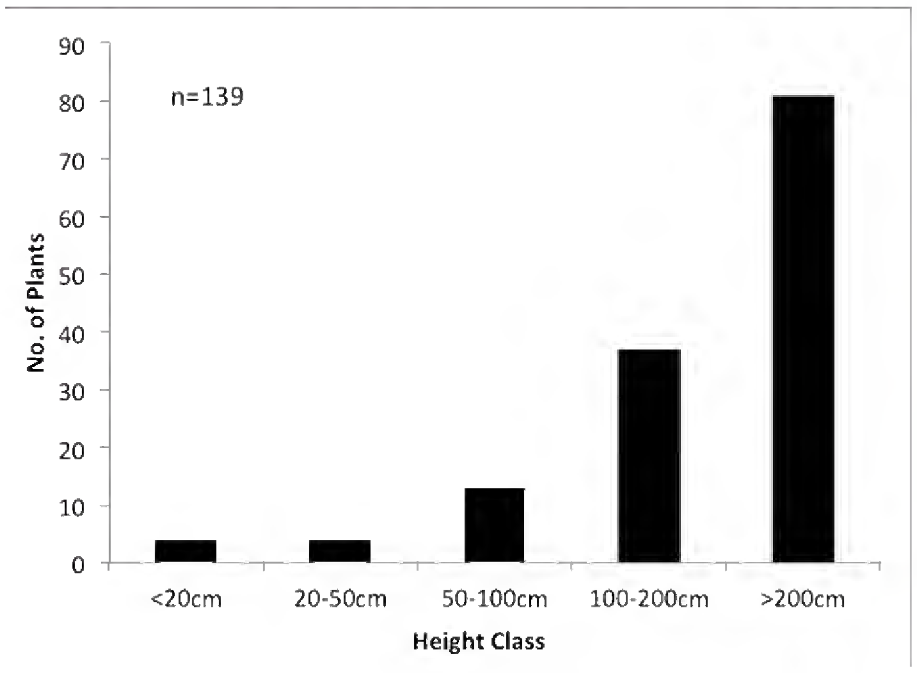

Fig. 3b. Distribution of plant heights in population 1c. The populations at sites 3a and 1c are skewed towards larger, older plants, and there are very few small (young) plants.

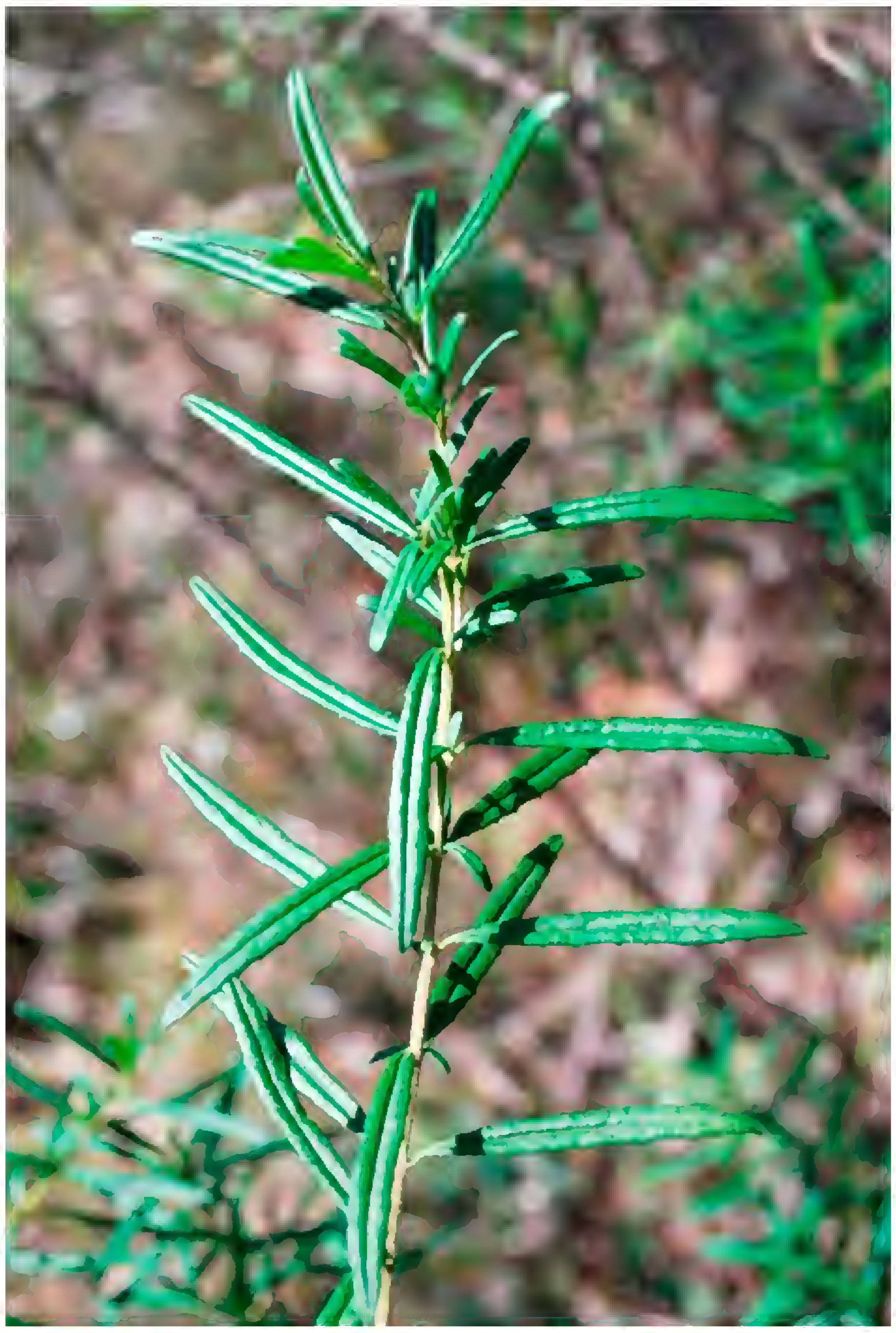

Fig. 6. Leaves of *Prostanthera tallowa* (population 2).

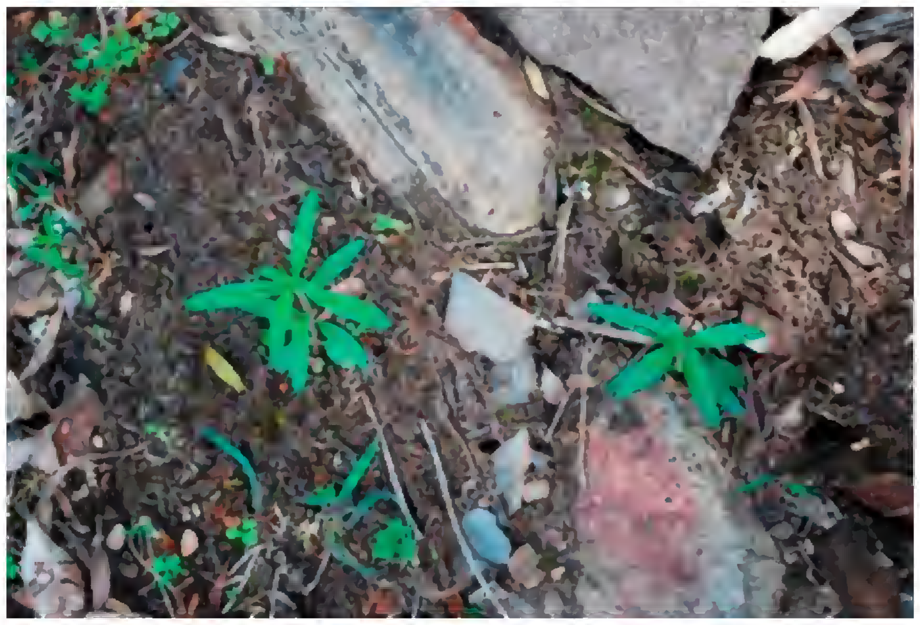

Fig. 4. Seedlings of *Prostanthera tallowa* in population 2.

General observations

Height classes for the plants counted in populations 1c and 3a show populations are skewed towards larger, older plants,and there are very few small (young) plants (Table 3, Figure 3a,b). The height (comparative age) distribution pattern exhibited in these populations is similar to that observed in the other populations of this species; that is, a dominance of older plants. The tallest plants of *Prostanthera tallowa* observed were over 4 m in height; these had a spread of up to 4 m, with several main branches. A small and obviously long unburnt gully within population 3a contained 27 plants over 3 m tall, while many plants in population 1d were over 3 m tall. The tallest plants in all populations are generally spindly and somewhat sparse in their foliage; some specimens have a substantial trunk. Dead branches are common on many of the tallest (oldest) plants, no doubt because of the exposed locations where they occur, the dry and windy conditions and possibly the age of the plants. Virtually no dead plants were found, although in very dry periods, some small plants were severely wilted.

Conn and Wilson (2012) report the main flowering period for this species as November to March but in this study at least a few flowers were observed in most months, including May and June. Plants were flowering quite heavily in the populations to the west of Tallowa Dam when visited on 5 January 2014. Occasional fruit were observed in all populations in 2013.

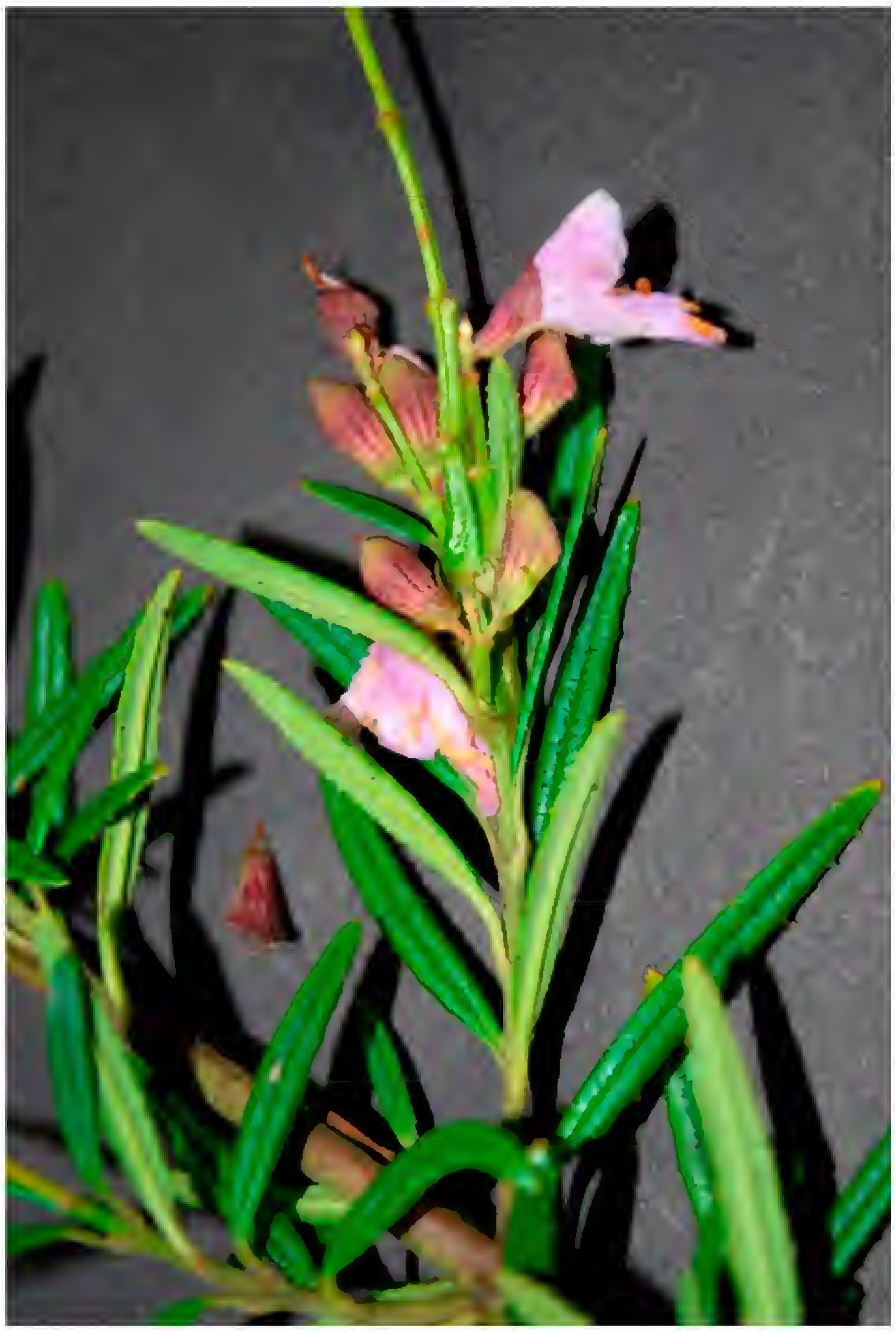

Fig. 7. Specimen of *Prostanthera tallowa* collected from population 3a.

Browsing, most likely by Swamp Wallabies *Wallabia bicolor*, was observed in some populations. Goats are another potential browser, but no recent evidence of goats was observed along the escarpments searched, although old dung was found in caves near Tallowa Dam. Browsing, whether by native or feral herbivores, is not considered a significant threat to this species.

Discussion

The field surveys found a considerably broader distribution and larger population size than the estimated population of 50 plants at one site (population 1c here) in Conn and Wilson (2012). The known total population has been expanded to over 3,300 plants, distributed over a range of 14 km, although the actual area of occupation is small, a matter of a few hectares in total. There is great deal of intervening and surrounding sandstone country, which has not been searched, but is likely to contain more populations as it has similar habitat.

The dominance of large (presumably old) plants in all populations and the lack of small (young) plants suggest that the species regenerates following fire. Most species of *Prostanthera* are fire sensitive, regenerating by seed after fire. Some species re-sprout after fire, but there was no evidence of suckering by *Prostanthera tallowa*.

All the localities where the plants occur, except locality 4, were burnt in January 2003 (NPWS, Nowra, pers. comm., October 2013). After 10+ years without fire, the great majority of the populations contain old plants although obviously senescent plants are almost unknown. There are almost no seedlings. Fires that are either too frequent or too infrequent can have a detrimental effect on species associated with the sandstone country, where severe fire is a fundamental element of vegetation ecology. The locations where the *Prostanthera* plants grow experience severe fire from time to time, although this can be militated by the rocky character of most sites. The large plants in population 3a probably escaped burning in the 2003 fire because of the nature of the surrounding rock.

Almost all populations of *Prostanthera tallowa* occur within protected conservation areas, including the Sydney Water Special Area around Tallowa Dam, which is a protected catchment managed for water harvesting. The small population at locality 4 is just outside Bugong National Park. Threats to the species are minimal, particularly with the discovery of the large and distant populations within Morton State Conservation Area.

Few sites have suffered from human disturbance. At the Tallowa Dam locality, plants occur along the edges of the access road and below the adjacent power line. Clearing below the power line and road maintenance no doubt regularly destroy some plants, although the larger populations are away from this area. The Sydney Catchment Authority maintains

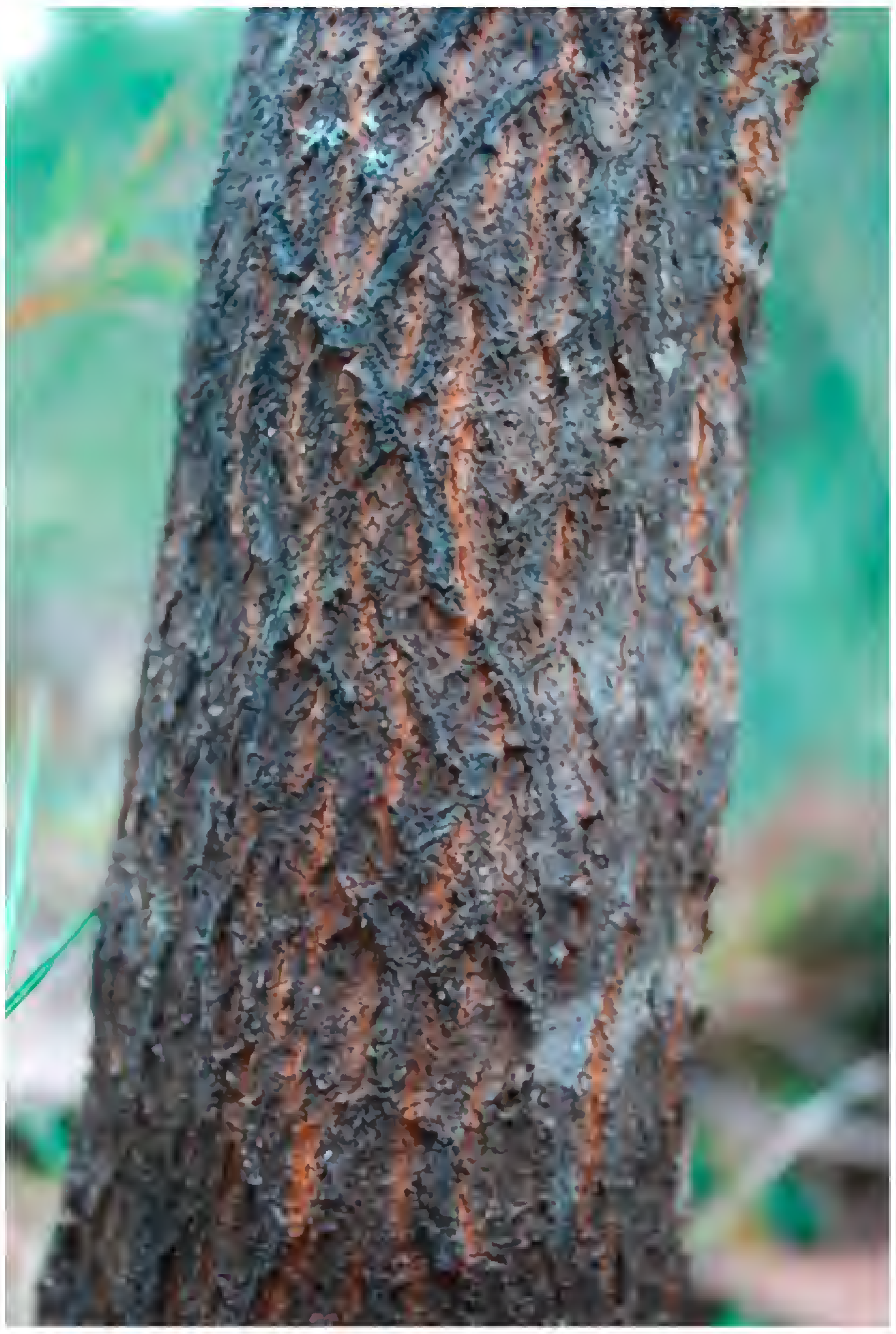

Fig. 8. Bark on an old plant of *Prostanthera tallowa.*

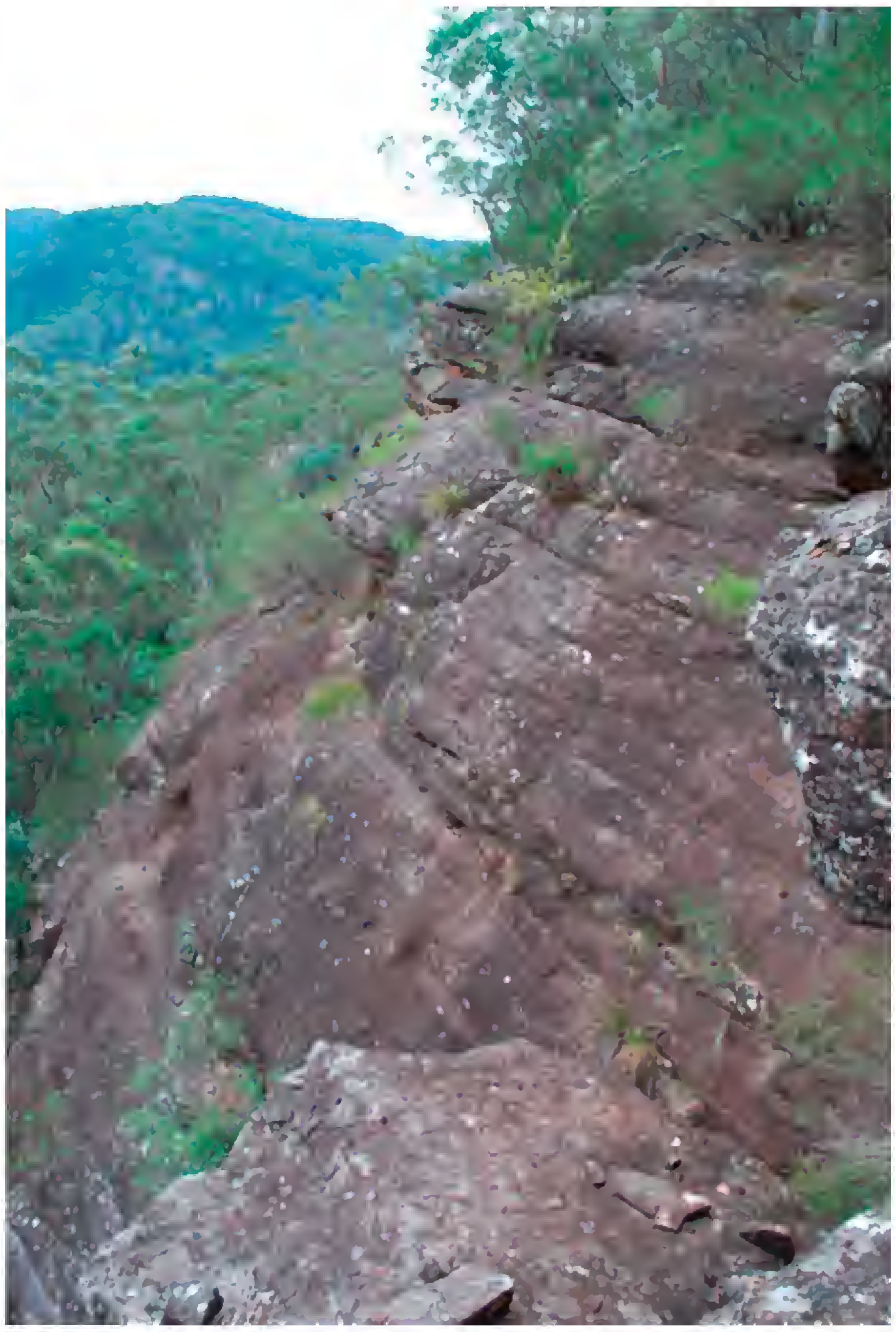

Fig. 9. Cliff habitat of *Prostanthera tallow* at population 1d.

a survey station on the escarpment within population 1d. The access track is overgrown with little evidence of recent clearing at the survey station. Plants of *Prostanthera tallowa* grow around the survey station and the end of the access track. Minor threats exist along the escarpment at locality 3 where there is evidence of sandstone boulders being stolen; vehicle access is not possible but there is a parking area nearby. However, given its limited distribution and small area of occupation, albeit almost totally within protected areas, *Prostanthera tallowa* is worthy of consideration for listing as vulnerable under the *Threatened Species Conservation Act 1995* (NSW).

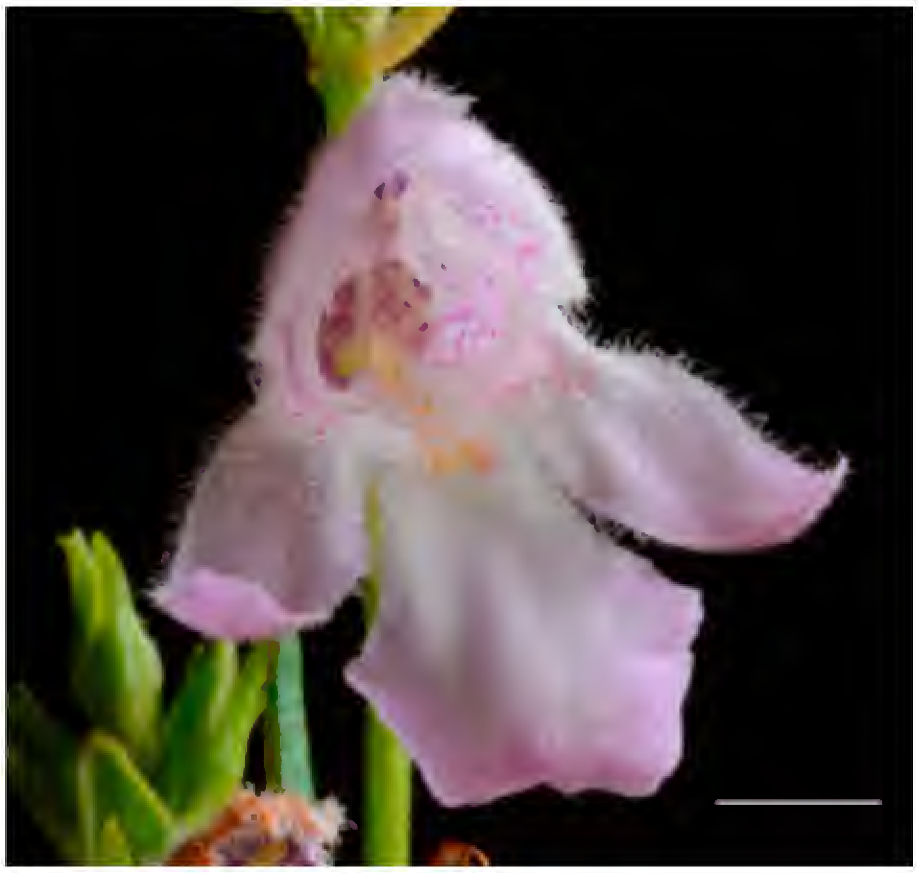

Fig. 10. Flower of *Prostanthera tallowa* in population 1h. (Scale bar = 5 mm).

Conclusion

The field surveys for the rare shrub *Prostanthera tallowa* in 2013–2014 extended the range of the population from Tallowa Dam (in the Central Coast Botanical Sub-Division) 14 km to the southeast and into the South Coast Botanical Sub-Division. The study found that the known populations of the species contain over 3,300 plants in four distinct localities containing 18 separate populations. It appears that plants are killed by fire and regenerate by seedling after being burnt though the time required for plants to set viable seed, i.e. plant age, is still unknown; this information is critical to managing fire where the species grows.

There is no immediate threat to the species, given the new populations found in Morton State Conservation Area and the significant expansion of the distribution and population size at Tallowa Dam. The presence of this species needs to be considered in management decisions for Morton National Park and Morton State Conservation Area and Sydney Catchment Authority should take account of the existence of this rare species on land that they control at Tallowa Dam. Clearing below the power line and roadside maintenance near the dam have previously impacted on some plants and clearing activities require modification to avoid destroying plants of this species, which do not grow high enough to impact upon the power line. This is important at this location as the type locality is adjacent to the road.

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Three grass species recently recognised as naturalised in New South Wales, Australia

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AUSTRALIA

Abstract: Information is provided on three exotic species of Poaceae, *Alopecurus aequalis*, *Dichanthium aristatum* and *Sporobolus coromandelianus*, recently recognised as naturalised or at a stage of naturalising in the state of New South Wales, Australia. These species are superficially similar in appearance to related native species, hence the need for being aware of their possible presence and weed potential.

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Introduction

Information is provided on three species of Poaceae recently recorded or recognised (including cases where herbarium specimens have existed for some time) as naturalised or naturalising in New South Wales. This paper follows a format similar to that used by Hosking et al. (2011) for such species. These records were established while investigating specimen collections for the *Australia's Virtual Herbarium* (AVH), *Flora of Australia* and vegetation survey projects, leading to the preparation of treatments for *Alopecurus aequalis*, *Dichanthium aristatum* and *Sporobolus coromandelianus* for the *New South Wales Flora Online* (Kodela 2010, 2012a, 2012b).

This study is mainly based on investigations of herbarium specimen collections, assisted by assessing records in AVH (CHAH 2015). AVH (http://avh.chah.org.au/), the *Atlas of Living Australia* website (http://www.ala.org.au/) and *AusGrass2* (http://ausgrass2.myspecies.info/) provide further details on specimens, species and distributions in Australia.

Results

Alopecurus aequalis Sobol.

Orange Foxtail, Short-awned Foxtail, Short Awn Foxtail

Description: tufted perennial or sometimes annual grass to 0.6 m (or more) high, with erect to decumbent or spreading stems; often aquatic with partly submerged stems (Fig. 1). See Hubbard (1968), Walsh (1994), Holm et al. (1997), Doğan (1999), Sharp & Simon (2002), Jessop et al. (2006), Kodela et al. (2009), Kodela (2010) and Simon & Alfonso (2011).

Region of origin: mainly temperate Northern Hemisphere; Eurasia, northern Africa and North America.

New South Wales distribution/habitats: Southern Tablelands, South Western Plains, South Far Western Plains: occurs in the Kosciuszko area (where first collected on the Cooleman Plain in 1969) and probably extending west to the far south-western part of the state (see Kodela et al. 2009). Most specimen records of naturalised collections from western New South Wales (e.g. Yenda–Hay–Barham and

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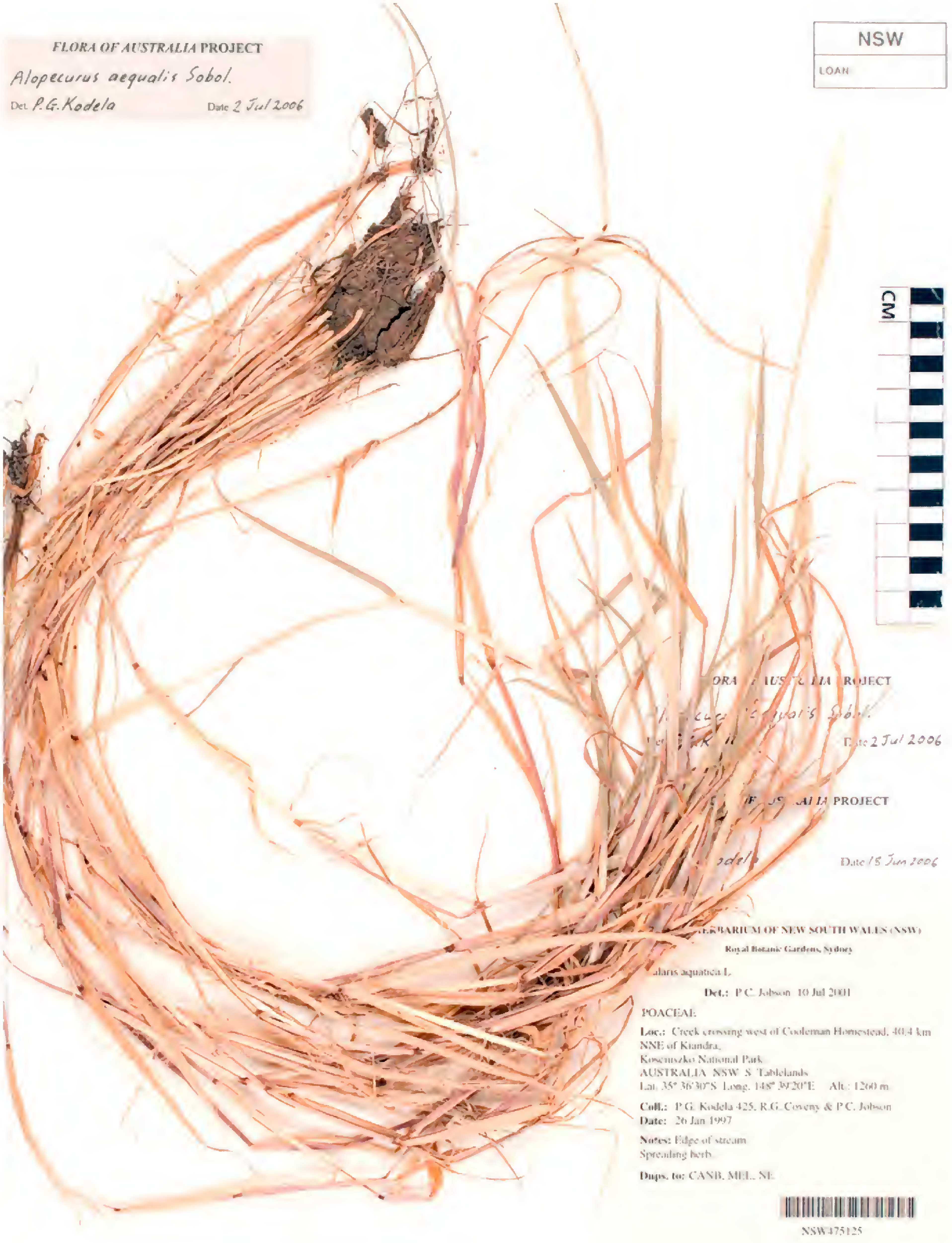

FLORA OF AUSTRALIA PROJECT
Alopecurus aequalis Sobol.
Det. P.G. Kodela Date 2 Jul 2006
NSW
LOAN
CM
Date 2 Jul 2006
PROJECT
Date 15 Jun 2006
ERBARIUM OF NEW SOUTH WALES (NSW)
Royal Botanic Gardens, Sydney
alaris aquatica L.
Det.: P.C. Jobson 10 Jul 2001
POACEAE
Loc.: Creek crossing west of Cooleman Homestead, 40.4 km NNE of Kiandra,
Kosciuszko National Park
AUSTRALIA NSW S Tablelands
Lat. 35° 36'30"S Long. 148° 39'20"E Alt.: 1260 m
Coll.: P.G. Kodela 425, R.G. Coveny & P.C. Jobson
Date: 26 Jan 1997
Notes: Edge of stream
Spreading herb
Dups. to: CANB, MEL, NE
NSW475125

Fig. 1. *Alopecurus aequalis* specimen from Cooleman Plain, Kosciuszko National Park.

Wentworth regions) occur from 1945 onwards. Intriguingly, there are collections at the National Herbarium of Victoria from the late 19th century, *viz*. western interior of New South Wales, *C. Moore s.n.*, 1880, and Murrumbidgee [?River], *G.P. Day s.n.*, [probably from 1870s–1890s when Day was active], that would represent the earliest records. In Victoria, where *Alopecurus aequalis* appears to be more common, records go back to 1900. *Alopecurus aequalis* grows in wet places such as swampy areas, bogs, shallow pools, poorly drained areas (including ponded or depressed areas on plains in woodlands or shrublands), along streams, creeks and irrigation channels; to high altitudes (records to c. 1280 m in New South Wales).

Notes: this grass had previously been cited as occurring in New South Wales by Walsh (1994) but was only added to the *NSW Census of Plants* following its treatment in the *Flora of Australia* (Kodela et al. 2009). It should especially be checked against other species of *Alopecurus* in the Southern Tablelands to South Far Western Plains regions. *Alopecurus aequalis* is similar to, and has been confused with, the more common *Alopecurus geniculatus* (Marsh Foxtail, Knee-jointed Foxtail), but distinguished from it by having glumes about equal or slightly shorter than the lemma, lemma margins connate for at least of their length and the lemma awn usually 2 mm long or less, not conspicuously protruding beyond glumes and more or less straight.

Variation in specimens of *Alopecurus* 'aequalis' is described by Kodela et al. (2009) and Kodela (2010). Specimens from the Cooleman Plain have awns to 2 mm long attached just below the middle of the lemma at c. 2/5 of the lemma length from the base (similar to what occurs in *Alopecurus aequalis* specimens from overseas). Specimens from the Yanco-Berrigan-Hay-Barham area (South Western Plains) probably extending west to the Wentworth area (South Far Western Plains) also have inconspicuous lemma awns, however, in these specimens the straight to slightly recurved or outswept awns are often shorter (to 1.5 (–2) mm long), attached in the upper half of the lemma near the apex (to c. 0.5 mm or sometimes to 0.7 mm below the apex) and usually more conspicuously exceed the apex of the glumes (i.e. extend further), and the folded glumes are characteristically slightly sigmoid in shape (Fig. 2). This latter group of specimens includes the collections of Moore and Day from the late 19th century. It appears to be a distinct form or variant, but may represent another taxon; the specimens have not been able to be matched with any other species of *Alopecurus*. Alternatively, it may simply reflect variation in *Alopecurus aequalis* where the lemma awn can be inserted from c. midway to subapical. This variation also occurs in Victoria, where specimens with awns inserted higher on the lemma (as in most south-western New South Wales specimens) mainly come from the north-west of the State, *fide* N.G. Walsh (pers. comm.). There is also the possibility for hybrids between *Alopecurus aequalis* and *Alopecurus geniculaltus* (= *Alopecurus* ×*haussknechtianus* Asch. & Graebn.). Further investigation, including confirmation of specimen identifications, is required to determine the extent of distribution of *Alopecurus aequalis* in New South Wales.

Weed issues: *Alopecurus aequalis* is spread mainly by seed. Overseas it is a weed of crops, particularly in rice fields where it is a floating weed seed species (the seeds being dispersed by irrigation waters) (Li & Qiang 2009), and cereals such as wheat, barley and oats (Holm et al. 1997). It is a serious winter annual weed in both lowland and upland crops in Japan, and a major rice weed in Nepal (to 1900 m altitude) and the Philippines, as well as infesting rice in China, Taiwan and Hungary, and vegetables and vineyards (Holm et al. 1997). As a competitive weed *Alopecurus aequalis* can reduce cereal yields. The presence of this grass in the Murrumbidgee–Murray irrigation area and Riverina could indicate a potential for further spread and weed issues. *Alopecurus aequalis* is also an environmental weed, having been recorded in damp or ponded areas in eucalypt

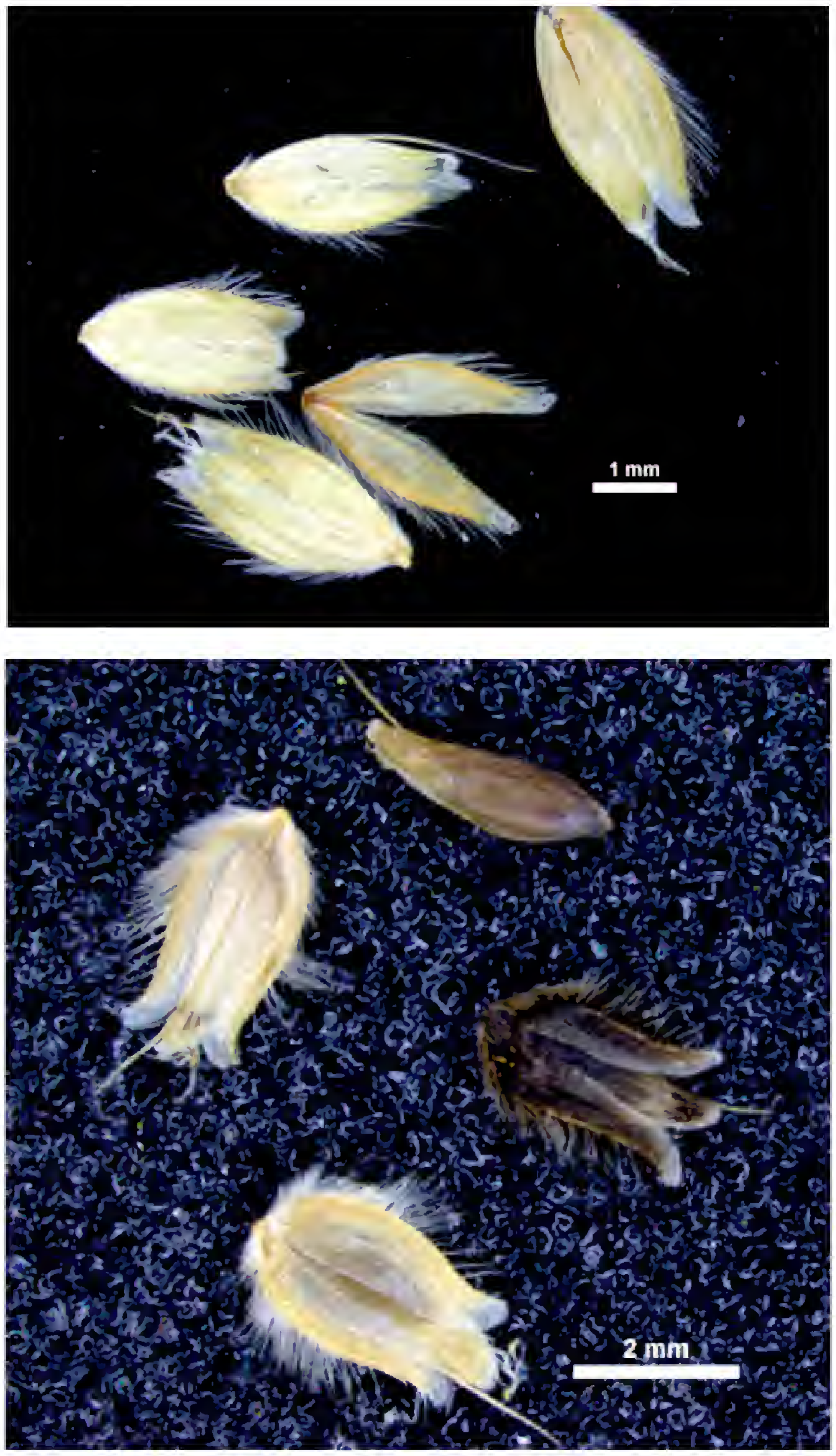
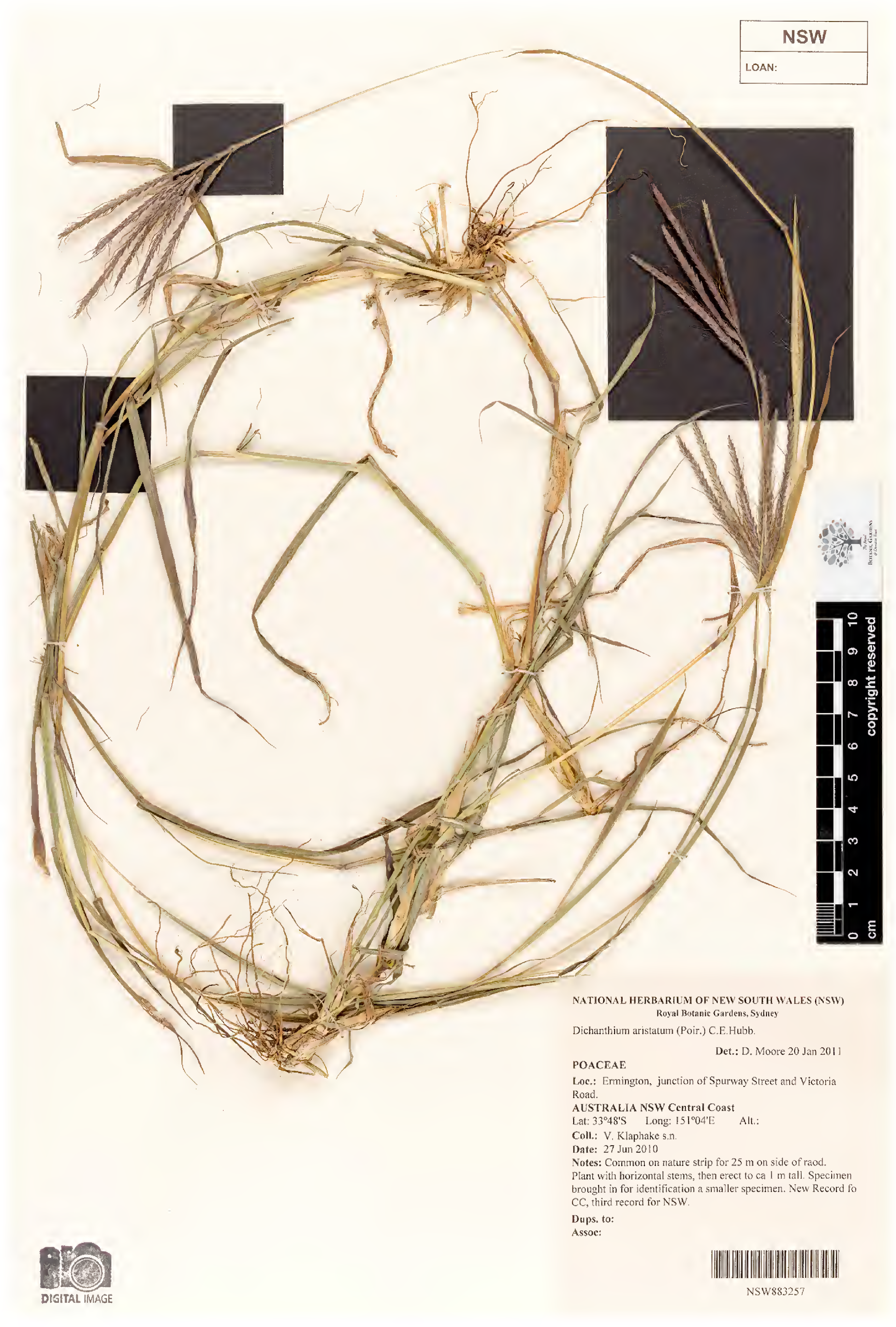


Fig. 2. Spikelets of *Alopecurus aequalis* showing glume shape a lemma awn position: (a) Cooleman Plain specimens with awn inserted on the lemma just below the midpoint; (b) western New South Wales specimens representing a possible 'variant' with awn on lemma inserted near apex and glumes more distinctly sigmoid.



NATIONAL HERBARIUM OF NEW SOUTH WALES (NSW)
Royal Botanic Gardens, Sydney

Dichanthium aristatum (Poir.) C.E.Hubb.

Det.: D. Moore 20 Jan 2011

POACEAE

Loc.: Ermington, junction of Spurway Street and Victoria Road.

AUSTRALIA NSW Central Coast

Lat: 33°48'S Long: 151°04'E Alt.:

Coll.: V. Klaphake s.n.

Date: 27 Jun 2010

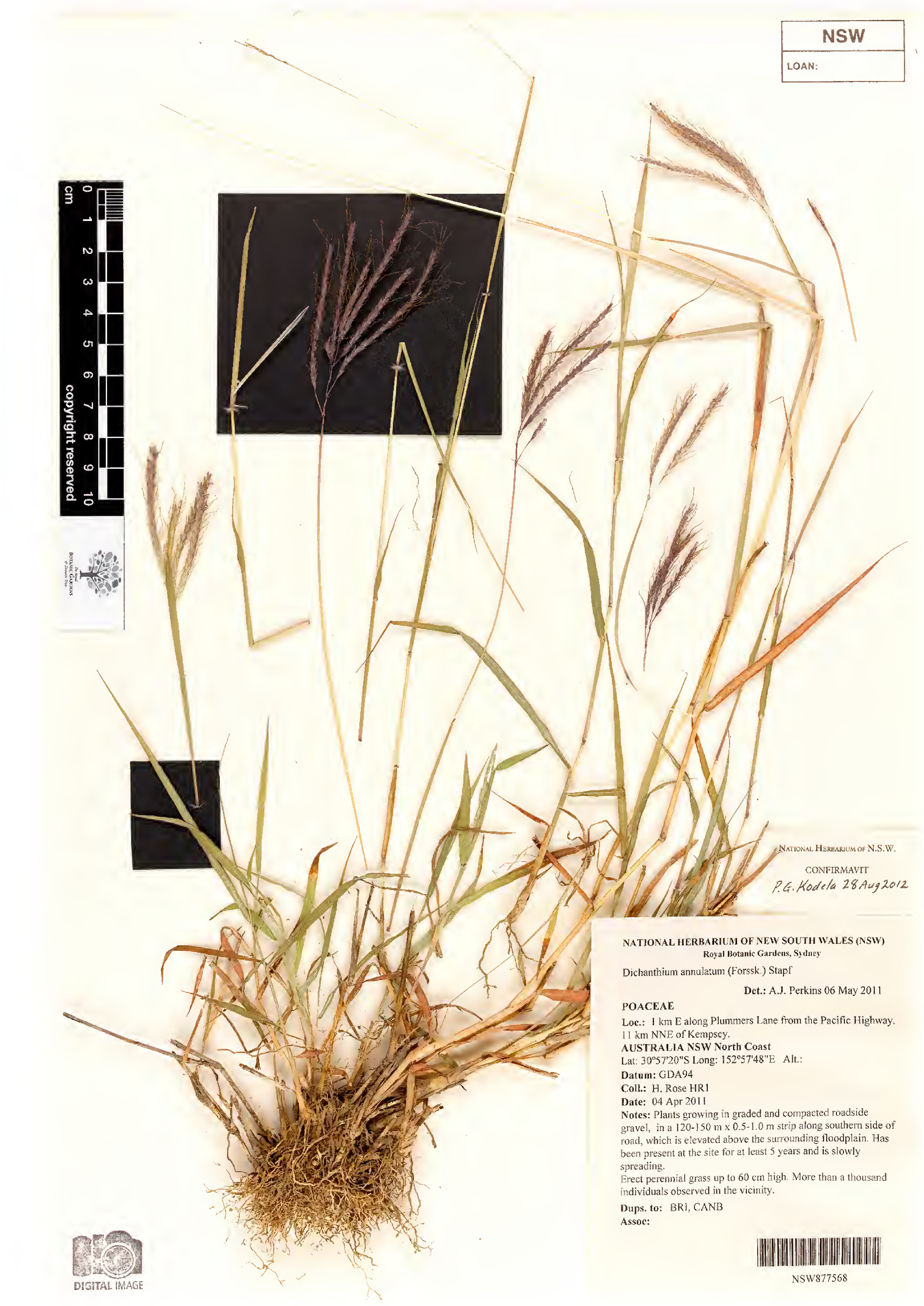
Notes: Common on nature strip for 25 m on side of raod. Plant with horizontal stems, then erect to ca 1 m tall. Specimen brought in for identification a smaller specimen. New Record fo CC, third record for NSW.

Dups. to:

Assoc:

NSW883257

Fig. 3. *Dichanthium aristatum* specimen from Ermington, near Parramatta.



NATIONAL HERBARIUM OF N.S.W.
CONFIRMAVIT
P.G. Kodela 28 Aug 2012

NATIONAL HERBARIUM OF NEW SOUTH WALES (NSW)
Royal Botanic Gardens, Sydney

Dichanthium annulatum (Forssk.) Stapf

Det.: A.J. Perkins 06 May 2011

POACEAE

Loc.: 1 km E along Plummers Lane from the Pacific Highway. 11 km NNE of Kempsey.
AUSTRALIA NSW North Coast
Lat: 30°57'20"S Long: 152°57'48"E Alt.:
Datum: GDA94
Coll.: H. Rose HR1
Date: 04 Apr 2011
Notes: Plants growing in graded and compacted roadside gravel, in a 120-150 m x 0.5-1.0 m strip along southern side of road, which is elevated above the surrounding floodplain. Has been present at the site for at least 5 years and is slowly spreading.
Erect perennial grass up to 60 cm high. More than a thousand individuals observed in the vicinity.
Dups. to: BRI, CANB
Assoc:

NSW877568

Fig. 4. *Dichanthium annulatum* specimen from near Kempsey.

woodlands and on saltbush plains in New South Wales (based on herbarium records) and mallee bioregions in Victoria (The State of Victoria Department of Sustainability and Environment 2009), as well as creeks in a boggy subalpine area in Kosciuszko National Park. It is able to infest shallow aquatic habitats. *Alopecurus aequalis* is non toxic.

Alopecurus species in Australia are normally considered exotics that have been introduced and become naturalised. However, early records and the possibility for wetland plants to be dispersed long distances by agents such as migratory waders warrants questioning the status of *Alopecurus* taxa or some populations of *Alopecurus* in Australia; many wetland species have widespread cosmopolitan or disjunct distributions.

Dichanthium aristatum (Poir.) C.E.Hubb.

Angleton Grass

Description: tufted perennial, with stolons; prostrate to semi-erect, becoming erect to 1 (–1.8) m high at maturity (Fig. 3). See Gould (1975), Bisset & Sillar (1984), Skerman & Riveros (1989), Sharp & Simon (2002), Cook et al. (2005), Simon & Alfonso (2011), Kodela (2012a) and Pastures Australia (undated).

Region of origin: India to south eastern Asia.

New South Wales distribution/habitats: North Coast (records in far north-eastern part of the State) and Central Coast: uncommon, with isolated records from a rural area outside Tyalgum (near a house), a roadside near Kyogle where it was possibly planted (also possibly at nearby Rukenvale in a mown lawn), and common on a nature strip at Ermington (a Sydney suburb near Parramatta). The earliest records in New South Wales are from the Kyogle area collected in 1993, however with uncertain status regarding degree of naturalisation. In Queensland it grows in urban areas (e.g. footpaths, lawns), roadsides (often mown or slashed), grasslands, scrub, woodlands, riverbanks, grassy plains, floodplains, damp ground and coastal dunes; usually disturbed sites.

Notes: partly introduced in Australia as a fodder plant in pastures in tropical areas (more common and widespread in Queensland, largely due to natural spread/naturalisation; scattered records from Western Australia and the Northern Territory). The first record in Australia is from a plant cultivated in the Sydney Botanic Gardens in 1912, with the earliest naturalised occurrences recorded in Queensland where it was also grown in nurseries and introduced to paddocks (Bisset & Sillar 1984). Other possible sources of introduction, such as straw packing from India, are described by Bisset and Sillar (1984). Occurrences in New South Wales include roadsides, indicating *Dichanthium aristatum* may have been planted in these areas or has spread (or could spread) via roadways which are effective weed corridors. It is grown at Tamworth and has been used in pasture trials in northern New South Wales (John Hosking, pers. comm. 2012; also Lodge & Harden 2009, Lodge et al. 2010, McGufficke & McCormick 2010, Harris et al. 2014). Differs from native species of *Dichanthium* occurring in New South Wales by having the base of its racemes bare without spikelets (natives have sessile or subsessile racemes bearing spikelets to the base). This can cause confusion when identifying specimens using some keys and floras, i.e. when *Bothriochloa* is separated from *Dichanthium* by having racemes bare at the base (however this occurs in both genera), or when *Dichanthium* is described as having an “inflorescence of sessile or subsessile racemes bearing spikelets to the base” (Jacobs et al. 2008: 206) when this is not the case in *Dichanthium aristatum* (which can be distinguished by its raceme bases and upper part of peduncles being silky-hairy). *Bothriochloa* can generally be separated by having pedicels with a longitudinal depression or groove either side (dumb-bell-shaped in cross-section) while in *Dichanthium* the pedicels are without a longitudinal depression (they are circular or elliptical in cross-section).

Dichanthium annulatum (Forssk.) Stapf (Sheda Grass), also apparently recently introduced in New South Wales (Perkins undated), has been recorded as spreading in a roadside strip of gravel along Plummers Lane, E of the Pacific Highway, c. 11 km NNE of Kempsey (North Coast; Fig. 4) and possibly along a roadside at Gravesend (North Western Slopes), also has bare raceme bases (i.e. spikelets not to base) but differs from *Dichanthium aristatum* by the raceme axis below the basal spike being glabrous (hairy in *Dichanthium aristatum*; illustrated in Anon. 2011) and having longer hairs on its glumes especially in upper parts. Previous confusion has occurred between the species (e.g. in White 1930), and differences are described by Bisset and Sillar (1984). While more common in Queensland, the status of *Dichanthium annulatum* in New South Wales regarding degree of adventive spread or naturalisation requires further investigation.

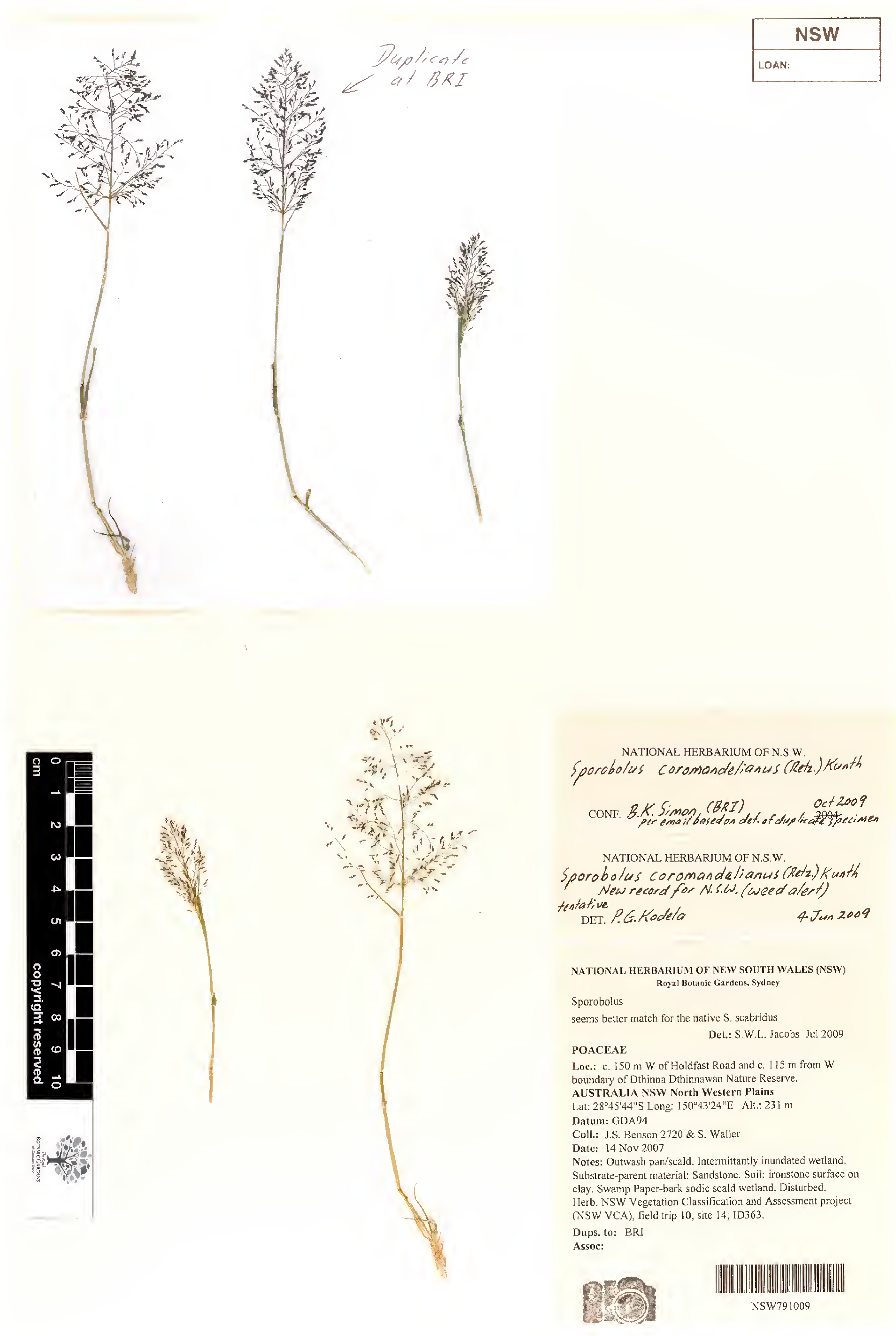
Weed issues: *Dichanthium aristatum* spreads by seed and expands slowly by stolons (Cook et al. 2005, Pastures Australia undated). It has the potential to invade degraded native pasture (e.g. competitive advantage in speargrass pastures), heavily grazed paddocks, old cultivation areas and roadsides (e.g. disturbed by grading) and other disturbed areas (Bisset & Sillar 1984, Pastures Australia undated). While seen as a potential useful plant it also is a possible weed as it will colonise natural woodlands and grasslands, particularly in cracking clay soils. *Dichanthium aristatum* is non toxic.

Sporobolus coromandelianus (Retz.) Kunth

Small Dropseed, Madagascar Dropseed

Description: annual or ephemeral tufted grass to 30 cm high, culms erect or geniculately ascending (Fig. 5). See Cope (1982), Simon & Jacobs (1999), Sharp & Simon (2002), Simon (2005), Wu & Phillips (2006), Simon & Alfonso (2011), Kodela (2012b) and Pathak & Singh (2013).

Region of origin: Old World Tropics, including Africa and SW Asia.



NATIONAL HERBARIUM OF N.S.W.
Sporobolus coromandelianus (Retz.) Kunth

CONF. B.K. Simon, (BRI) Oct 2009 ~~2004~~
per email based on det. of duplicate specimen

NATIONAL HERBARIUM OF N.S.W.
Sporobolus coromandelianus (Retz.) Kunth
New record for N.S.W. (weed alert)
tentative
DET. P.G. Kodela 4 Jun 2009

NATIONAL HERBARIUM OF NEW SOUTH WALES (NSW)
Royal Botanic Gardens, Sydney

Sporobolus

seems better match for the native S. scabridus

Det.: S.W.L. Jacobs Jul 2009

POACEAE

Loc.: c. 150 m W of Holdfast Road and c. 115 m from W boundary of Dthinna Dthinnawan Nature Reserve.
AUSTRALIA NSW North Western Plains
Lat: 28°45'44"S Long: 150°43'24"E Alt.: 231 m
Datum: GDA94
Coll.: J.S. Benson 2720 & S. Waller
Date: 14 Nov 2007
Notes: Outwash pan/scald. Intermittantly inundated wetland. Substrate-parent material: Sandstone. Soil: ironstone surface on clay. Swamp Paper-bark sodic scald wetland. Disturbed. Herb. NSW Vegetation Classification and Assessment project (NSW VCA), field trip 10, site 14; ID363.

Dups. to: BRI
Assoc:

NSW791009

Fig. 5. *Sporobolus coromandelianus* specimen from near Yetman.

New South Wales distribution/habitats: North Western Plains: Yetman area; first collected 2007 from near Dthinna Dthinnawan Nature Reserve from an outwash pan/scald of an intermittently inundated wetland. This is the only known record in New South Wales to date. Usually grows in disturbed sites, pasture areas, grassland, woodland, in clay to sandy soils; weed of gardens and roadsides; appears to be spreading (Simon 2005).

Notes: mostly isolated occurrences in subtropical and tropical Australia (Simon 2005) with most records in Australia from Queensland; first record for New South Wales resulted from a specimen collected during a regional vegetation survey in 2007. *Sporobolus coromandelianus* differs from the superficially close native *Sporobolus australasicus* Domin by the spikelets being arranged towards the apices of the panicle branches (Simon 2005, Simon & Alfonso 2011). Also similar to *Sporobolus caroli* Mez. which has all spikelets distinctly pedicellate.

Weed issues: *Sporobolus coromandelianus* is spread by seed (and vegetatively). Mainly a weed of disturbed areas, but noted by Simon (2005) that it appears to be spreading, and this includes occurrences in natural areas.

Discussion

All three species, *Alopecurus aequalis*, *Dichanthium aristatum* and *Sporobolus coromandelianus*, are recognised weeds (Randall 2002), and have the potential to spread in New South Wales. The above findings demonstrate the value and need of being alert for new records while undertaking vegetation surveys, herbarium curation and specimen-based research, especially in groups like grasses where introduced taxa can superficially look similar to native species. The findings also demonstrate the need to monitor for the possible escape, spread, and naturalisation of exotic species planted in pastures, parks, gardens and along roadsides.

Acknowledgements

Bryan Simon (formerly BRI) kindly confirmed identification of the *Sporobolus*, Val Stajic and Neville Walsh (both MEL) provided details and useful comments on the *Alopecurus*, and Andrew Perkins (formerly NSW) contributed to our knowledge of *Dichanthium* in New South Wales. MEL helpfully provided access to their herbarium collections. I am grateful for useful comments on the manuscript by Doug Benson and John Hosking. The figure of the *Alopecurus* specimen sheet is based on a digital photo by Harry Brian, and images of the spikelets were taken with the assistance of Andrew Orme. I wish to take this opportunity to acknowledge the significant scientific contributions of Bryan Simon who sadly passed away in 2014. He generously shared his knowledge, ever helpful in addressing my inquiries about grasses over the years.

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Myxomycetes (slime moulds) of arid to semi-arid areas of northwest New South Wales, Australia

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Abstract: Myxomycetes (plasmodial slime moulds) were studied along an east-west traverse extending across the arid and semi-arid zones in northwest New South Wales bounded by Lake Cargelligo (400 mm annual rainfall), Bourke (400 mm annual rainfall), Tibooburra (200 mm annual rainfall) and Menindee (250 mm annual rainfall). Samples of tree bark were collected from a range of trees, and subsequently myxomycetes were obtained in the laboratory with the use of the moist culture method. A total of 43 species were recognized. The assemblages of myxomycetes recorded did not change significantly across these climate zones, and, for samples with a reasonable number of species present, there was little difference in diversity due to tree-bark type. The assemblage of species present along this traverse is similar to arid and semi-arid zone tree bark assemblages elsewhere in Australia, which is consistent with the occurrence of one assemblage throughout.

About half of this assemblage consists of widely distributed species likely to be recorded anywhere in the world (cosmopolitan), although these species are found in relatively few samples. The other half of the assemblage is made up of species with a more restricted distribution (generally found in one region of the world or relatively rare worldwide); these species were found in most samples. These restricted distribution species have centres of distribution at a similar latitude and climate in the northern hemisphere.

The assemblage of species associated with bark in the higher rainfall areas of Australia has some of the species of the arid and semi-arid zones; it has most of the widely distributed species and very few of the restricted distribution species. The boundary zone between the two assemblages of species is likely to be near the outer margin of the semi-arid zone.

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Introduction

Myxomycetes (plasmodial slime moulds) are a small group of fungus-like organisms with a two-stage life cycle; a single nucleate phase (amoeboid or flagellated), and a multi-nucleate (single cell) phase starting as a plasmodium and ending as a fruiting body (containing spores) generally 0.5-2 mm high. Identification is based on the dried fruiting body.

During the last 10 years there have been numerous studies of the myxomycete biota of the world's arid and semi-arid areas (e.g., Novozhilov & Schnittler, 2008; Lado et al., 2011) and many of these areas have been found to have more species than expected (Lado et al., 2011). However, in arid and semi-arid areas in Australia, myxomycetes have been poorly studied.

Pre-1995 studies of Australian myxomycetes were summarised by Mitchell (1995). Subsequent work, involving both field collections and moist chamber culture collections, has been directed primarily towards increasing the number of species known from Australia, their regional distributions and host substrates such as wood, bark and litter (Ing & Spooner, 1994; McHugh et al., 2003; Jordan et al., 2006); Rosing et al, 2007; Davison et al, 2008; McHugh et al 2009; Knight & Brims, 2010). Studies have also been carried out on myxomycetes associated with lianas (Wrigley de Basanta et al., 2008) and with snowbanks (Stephenson and Shadwick, 2009). Most of this work has been based on collections from the higher rainfall areas (>600 mm mean annual rainfall) around the edge of the continent. There has been little study of low rainfall areas; the information available consists of specimens deposited in herbaria and one published study of the myxomycetes of the northern Simpson Desert (Davison et al., 2008).

The arid and semi-arid areas comprise about 75% of the Australia continent (Fig. 1) and their extent is a function of both rainfall and potential evaporation. This is expressed in the Köppen climate classification and its modifications (McKnight & Hess, 2000). The arid area is hot arid (BWh), and the semi-arid area hot in the north (BSh) and cool in the south (BSk). These areas are mapped using the latest climate data is the 'Seasonal rainfall zones of Australia' of the Bureau of Meteorology (www.bom.gov.au). In the north, the semi-arid area is bounded by 350-650 mm mean annual rainfall and in the south by 250–500 mm annual rainfall, so the arid zone is bounded in the north by the 350 mm annual rainfall, and in the south by 250 mm annual rainfall. The minimum mean annual rainfall in central Australia is about 150 mm. Associated with this increase in aridity toward the centre of Australia is an increase in mean maximum temperature, and an increase in the variability in rainfall. Plants and other organisms may also be affected by two north-south changes across Australia: (1) decrease in mean average temperature away from the equator, and (2) the change from rainfall having a very-marked summer maximum (November to March) in the north, to an average rainfall occurring uniformly throughout the year in the south.

The present study examines changes in the assemblages of myxomycetes in an east-west direction from the middle of the semi-arid zone to near the greatest aridity in the arid zone, studying the effect of increasing mean aridity and increasing rainfall variability (rather than addressing any changes in the myxomycete assemblages in the north-south direction).

Materials and Methods

In the study area (Fig. 1) climate ranges from semi-arid with a 400 mm annual rainfall and a vegetation of open woodland with grasses underneath, to arid with 200 mm annual rainfall, and grassland vegetation with scrub covered sand-dune hills and a few tree-lined drainage channels.

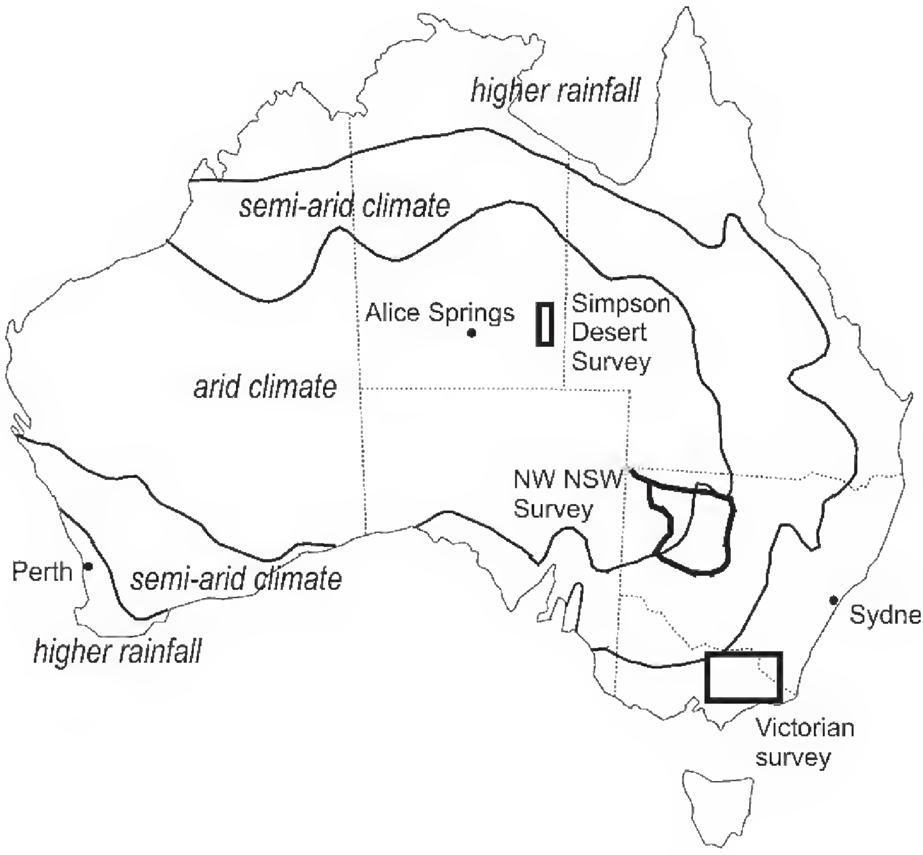

Fig. 1. Location of myxomycete surveys, and distribution of arid and semi-arid climate in Australia. Surveys: NW NSW (present study), Simpson Desert (Davidson et al., 2008), Victorian (Rosing et al. 2007).

Field collecting of visible myxomycete fruiting bodies is impractical because they would have to be targetted 1-2 weeks after major rainfall events, when many outback roads are closed or impassable. The alternative to field collections is to collect potential substrates and culture myxomycetes in moist chamber culture. Many different types of substrates contain myxomycete spores and microcysts, but the greatest number of myxomycete species are generally found on tree bark, so this survey concentrated on tree bark, but also included some herbivore dung, twigs on the ground, and one sample of lianas. The samples for this study were collected during dry weather in winter (11-19 August 2013), when myxomycetes are usually dormant.

The samples were collected along roads in northwest New South Wales that form a roughly square path, with sides about 300 km, and with corners near the towns Lake Cargelligo (400 mm annual rainfall), Bourke (400 mm annual rainfall), Tibooburra (200 mm annual rainfall) and Menindee (250 mm annual rainfall). The annual rainfall range over the study area is typical or comparable to the rainfall occurring in a large part of central Australia. To put this in context, except for a (generally) narrow coastal region, the wettest average annual rainfalls in Australia are generally about 600 mm per year, and the driest in central Australia, about 150 mm.

Within the study area the mean maximum monthly temperatures range from 32–37°C in January and from 15–18°C in July, so bark is likely to be dry for much of the time between rainfall events, and the temperature is high enough for myxomycete growth during rain events from January to July.

For our study the summer-autumn rainfall for the prior six months had been slightly less than normal, and for most of the area rainfall had stopped more than one month prior to the sampling. The rainfall consisted of distinct rainfall events of 5–25 mm, separated by periods of 7 to 30 days with no rain. A similar rainfall pattern occurred along the length of the area surveyed.

Sample localities and types of sample material collected are listed in Appendix 1. Samples were collected in paper bags. For tree bark a single mixed sample was collected, with the sample consisting of small pieces of dead bark from living trees, about 1.5 m above ground level, from all sides of the tree trunk, and optimally from 3-4 trees of the same species. Tree bark samples were preferably taken within groves of trees so that, with greater shading, the drying of the bark would be slower. Dung samples were of weathered dung collected over an area of 4 m across; if the dung from more than one animal species was present, then all dung types were collected.

The samples were stored in a cool, dry place until processed. The moist culture method used was that described by Stephenson and Stempen (1994). Petri dishes 90 mm in diameter were used, with a single layer of filter paper placed on the bottom. Samples were placed on top of the filter paper with the weathered surface of the bark uppermost. Five replicate Petri dishes were prepared for each sample. The individual pieces of bark comprising the sample were cut or broken up into postage stamp sized fragments before they were put in a Petri dish. Fragments from the same piece of bark were divided among five Petri dishes so that, with the slight variations in growth conditions among the Petri dishes, there was a greater likelihood of obtaining at least one fruiting.

Petri dishes were half filled with distilled water, covered, left for 24 hours, and then excess water was poured off. Dishes were kept covered, but not sealed, at about 22°C with only reflected daylight. Each week dishes were inspected with a stereomicroscope at 7x magnification, and the mature fruiting bodies removed, dried, and glued to small piece of cardboard. The moist culture of the bark and twig samples continued for between 2-3 months, and the dung samples for 3 months. Most samples were then dried out, rewet and monitored for a month. After both periods of drying out, mature fruiting bodies were removed from the non-weathered base of the samples.

Identification of the dried fruiting bodies of myxomycetes was carried out using Martin and Alexopoulos (1969), Nannenga-Bremekamp (1991), Ing (1999), Stephenson (2003), Poulain et al. (2011), and the website *Discover Life* (2015) (www.discoverlife.org). Temporary microscope slides were made by soaking the material in alcohol and 5% KOH solution. Semipermanent microscope slide mounts of many species were made to study the stalk, peridium, capillitium, and inflated spores by soaking the fruiting body in alcohol, then in 5% KOH solution, in water, and then in 'Brite' mountant (a USA furniture polish used for liverwort slides), and covering with a cover slip. Semi-permanent mounts of members of the Stemonitaceae were made by blowing spores off the fruiting body and gluing the latter horizontally in the air space of a cavity slide. The cavity was covered with a cover slip, fastened with 'Scotch' tape. Two groups that produced smaller fruiting bodies (*Echinostelium* and small sessile members of the genus *Licea*) were largely ignored in the study because of the poor sampling when looking for mature fruiting bodies at 7x magnification and the difficulty of definite identification with the microscopes available. It was not possible to identify some fruiting bodies that were few in number, malformed, partly colonized by fungi, or without enough features for identification.

List of species identified

The species of myxomycetes identified in our north western NSW study are listed below (Table 1) with information on the localities where each species was found. New records for Australia are *Clastoderma pachypus and Comatricha anomala*, whereas likely new species are *Arcyria sp. H* and *Cribraria sp. A*.

The species listed herein as *Cribraria sp. A* is described below.

Sporangia generally in small groups, erect, 0.3-0.4 mm total height. *Stalk* 0.2-0.3 mm long, translucent and ranging from pale yellow to brown, paler towards the top, longitudinally grooved, diameter 25-30 µm near the base and 4-6 µm at the top, narrowing mainly at the top. *Sporocyst* spherical to slightly obovoid, 0.07-0.09 mm diameter. *Cup* 1/3 to 1/2 the height of the sporocyst, upper margin smooth with no threads projecting, no net seen, and all spores lost easily; cup overall grey, with a diameter when flattened of 0.07 mm, mainly translucent, but grey colouring on some radials and along the edge; when the cup is flattened to a circle there are no tears formed across the cup, consistent with the cup being pleated when containing spores. *Spores* in dark violet in mass, light grey in transmitted light, slightly irregular in outline, ornamentation is small, even and spinulose, diameter 6.5-7 µm. This species is similar to *Cribraria zonatispora* Lado, Mosquera & Beltrán-Tej and *Cribraria fragilis* Lado & Estrada in not having a net, but it does not have the unusual spores of either of these.

Table 1. The species of myxomycetes identified in the north west NSW study. For each species, information is provided on the localities where it was found. When the samples were not on bark, then the type of substrate is indicated by D for dung, L for lianas, and T for twigs on the ground.

Arcyria cinerea (Bull.) Pers., 60A, 60B, 64C, 71A, 74A [C].

Arcyria cf. *cinerea* 67B **D** (brick red, similar to *Arcyria* sp. of Eliasson & Lundqvist, 1979).

Arcyria insignis Kalchbr. & Cooke, 62B **L** [C].

Arcyria sp H, 62A, 64C, 65A, 67A, 70C, 71A, 72A (for a description see McHugh et al., 2003, and Davison et al., 2008).

Badhamia versicolor Lister, 60A [NA, E, J]

Badhamia macrocarpa (Ces.) Rostaf, 60A, 60B, 64B, 82A [C].

Badhamia melanospora Speq., 73A **D** [E, NA]

Badhamiopsis ainoae (Yamash.) T.E. Brooks & H. W. Keller, 64A, 66A, 70B, 71B, 83A, 84A [NA, E, J].

Calomyxa metalica (Berk.) Nieuwl., 61A, 62C, 64A, 64B, 75A, 77A, 78A, 81A, 82A, 83A, 84A, 84B [C].

Clastoderma pachypus Nann.-Bremek., 65A [E + NA].

Comatricha anomala Rammeloo, 70A, 78B, 86A [E].

Comatricha ellae Hark, 62A, 62C, 64A, 64B, 64C, 64D T, 65A, 67A, 71A, 71B, 72A, 73B, 75A, 76A, 78B, 79A, 82A, 84A, 86A [E].

Comatricha laxa Rostaf., 71B, 84A [C].

Comatricha pulchella (C. Bab.) Rostaf., 67A, 76A [C].

Cribraria confusa Nann.-Bremek. & Y. Yaman, 76A [C].

Cribraria minutissima Schwein., 67A [C].

Cribraria sp. A, 64C, see text for description.

Dianema corticatum Lister, 64B, 66A, 70B, 71A, 71B, 73B, 74A, 77A, 79A, 80A, 82A, 83A, 84A [NA, E, J].

Didymium cf. decipiens, 63A, 70B, 77A, 78B, 84B, dark spores 16-17 µm.

Didymium dubium Rostaf.,62B **L**, 62C, 64C, 70B, 70C, 71A, 71B, 73A **D**, 73B, 76C **T**, 78B, 79A, 81A [C].

Didymium clavus (Alb. & Schwein.) Rabenh., 60A, 60B [C].

Enerthenema papillatum (Pers.) Rostaf., 60C, 65A, 67A, 73B, 75A [C].

Fuligo cinerea (Schweinitz) Morgan, 73A kangaroo **D**, 82B kangaroo **D** [C].

Lamproderma scintillans (Berk. & Broome) Morgan, 76C **T** [C].

Licea biforis Morgan, 64C, 71A, 71B, 73B, 78B, 79A, 81A, 82A, 83A, 84A [C].

Licea kleistobolus G. W. Martin, 60A, 64A, 64C, 70B, 70C, 71B, 75A, 76A, 77A, 78B, 79A, 80A, 82A, 83A, 84B [C].

Licea scyphoides T. E. Brooks & H. W. Keller, 64A [NH].

Macbrideola argentea Nann.-Bremek. & Y. Yamam, 64B [C].

Macbrideola oblonga Pando & Lado, 61A, 62C, 64A, 64B, 64C, 66A, 70A, 70C, 71B, 73B, 744A, 78A, 78B, 82A, 83A, 84A, 84B [southern E].

Macbrideola synsporos (Alexop.) Alexop., 61A, 62C, 64B, 66A, 78B, 80A, 82A, 83A [mainly southern E].

Paradiacheopsis fimbriata G. Lister & Cran.) Hertel ex Nann.-Bremek., 65A, 72A, 76C **T**, 86A [C].

Paradiacheopsis rigida (Brândza) Nann.-Bremek., 60A, 64B, 64C, 67A, 74A. [Northern Hemisphere temperate].

Perichaena depressa Lib., 73A **D** rabbit & kangaroo, 64D **T** [C].

Perichaena pedata (Lister & G. Lister) G. Lister, 82B kangaroo **D** [C].

Perichaena vermicularis (Schwein.) Rostaf., 60A, 62C, 64A, 64C, 66A, 70A, 70B, 70C, 71A, 74A, 76A, 77A, 78B, 82A, 82B **D**, 84A [C].

Physarum cinereum (Batsch) Pers., 76C **T** [C].

Physarum decipiens M. A. Curtis, 60B, 61A, 63A, 64A, 64B, 64C, 66A, 70B, 70C, 71A, 71B, 74A, 75A, 78B, 79A, 80A, 83A, 84A, 84B [NH].

Physarum decipiens 'heaped eggs' (possibly a variety of this species, greener, heaped and egg shaped), 62A, 62C, 62B **L**, 64B, 64C.

Physarum leucophaeum Fr., 62C, 71A, 81A [C].

Physarum robustum (Lister) Nann.-Bremek., 60A, 61A, 62C, 64B, 64C, 66A, 70B, 70C, 71B, 75A, 79A, 82A [E].

Reticularia olivacea (Ehrenb.) Fr., 60A, 70A, 71A [NA, E].

Stemonitopsis amoena (Nann.-Bremek.) Nann.-Bremek., 62B **L**, 64D **T**, 71A, 74A [E].

Trichia contorta (Ditmar) Rostaf., 60A, 62A, 64C [C].

Comparison of surveys

When comparing surveys, there are three factors to consider: (1) whether species are common between surveys, (2) the abundance of each species and (3) whether each species is, or is not, cosmopolitan.

One way of analysing the significance of the presence of a species is to look at its world distribution. The primary division is between cosmopolitan and non-cosmopolitan species. A distribution is classified as cosmopolitan where the species are widespread and common. The cosmopolitan species are marked by C in Tables 1 and 2. A distribution is classified as non-cosmopolitan where the species is uncommon or appears to be restricted to certain regions of the world. Table 2 shows two measures of whether the species is non-cosmopolitan. A measure of the world abundance of each species is given by the number of world herbarium records reported on *Discover Life* (2015) (www.discoverlife.org). Cosmopolitan species are generally sufficiently common to have over 300 records worldwide. A measure of the concentration of the distribution is derived from the distribution of the points on the world map of *Discover Life* (2015) (www.discoverlife.org) for each species, (the map not enlarged as this changes the cell size). On the world map each point represents one or more records in that area, and a measure of the concentration of the species is given by the number of points within the nominated concentration area (given in the species list below), compared with the total number of points on the map. Abbreviations used for regions of the world are [E] for Europe; [NA] for North America; [J] for the Japanese region of Asia; and [NH] for Northern Hemisphere.

Table 2. Distribution of selected myxomycetes in the relatively dry (arid and semi-arid) and relatively wet areas of Australia.

For Australian distribution, numbers indicate the number of sites where species have been recorded.

*** Samples in herbarium collections, as given in Discover Life (2015) (www.discoverlife.org).**

**** This column includes the sites of the eastern Victorian survey.**

# C, cosmopolitan; centres of species distribution: E, Europe; J, Japanese area of Asia; NA, North America; NH, Northern Hemisphere.

	Australia					World		
	arid and semi-arid areas			wetter areas				
	NW NSW, present study	Simpson Desert, Davison et al. (2008)	western arid and semi-arid	E Victoria, Rosing et al. (2007)	Australia wetter than semi-arid**	species distribution#	abundance	proportion in main area
	survey records	survey records	herbarium records*	survey records	herbarium records*		World herbarium records	World map cells with one or more records
Arcyria cinerea	5	1	3	3	17	C	6008	
Arcyria sp. H	8	1	1					
Badhamia macrocarpa	4				1	C	317	
Badhamiopsis ainoae	6					NA, E, J	123	16/18
Calomyxa metalica	12		1	1	3	C	365	
Comatricha anomala	3					E	102	6/6
Comatricha elegans		6	5		8	C	544	
Comatricha ellae	18		1		4	E	257	18/23
Comatricha laxa	2	9	2	2	11	C	947	
Comatricha pulchella	2		1		4	C	837	
Cribraria confusa	1		1	1	4	C	209	
Cribraria minutissima	1		1	1	11	C	176	
Dianema corticatum	13		1			NA, E, J	221	38/42
Didymium clavus	2				1	C	910	
Didymium cf. decipiens	5							
Didymium dubium	10				4	C	969	
Didymium squamulosum		1	1		15	C	4083	
Enerthenema papillatum	5			3	7	C	1495	
Licea biforis	10	4	2	1	4	C	346	
Licea kleistobolus	15	6	4	1	5	C	751	
Macbrideola oblonga	17	3	1			Southern E	181	8/12
Macbrideola synsporos	8			1		Southern E	82	10/13
Paradiacheopsis fimbriata	3	1	2	1	6	C	496	
Paradiacheopsis rigida	5					NHT	22	11/11
Perichaena vermicularis	15	1	3		5	C	1228	
Physarum decipiens	21	3	1			NH	678	57/60
Physarum leucophaeum	3		1		2	C	1573	
Physarum robustum	12		1			E	321	8/16
Reticularia olivacea	3				1	NA, E, J	197	25/29
Stemonitopsis amoena	2	2	1		1	E	176	13/19
Trichia contorta	3		2		3	C	1588	

Species distribution within the study area

Table 3 summarises the main results obtained for the 34 bark samples, excluding species found at only a single locality, and the one sample providing a single species (69A). A reasonable number of identified species was found in each sample, the samples had between one and 13 species, there was an average of 6.6 identified species per sample, and 12 samples had more than 7 identified species. A total of 43 species were recognized.

In this survey the abundant species are non-cosmopolitan, and the rarer species are cosmopolitan. Only about half of the species found in this survey are cosmopolitan indicating the composition of the assemblage is very unusual.

An important result from our survey is that no major change in the diversity of the myxomycete assemblages of was observed across an east-west traverse of the arid and semi-arid zones. Most species extended along the whole traverse without any change in the proportion of trees in which they are found or in the number of fruitings harvested from the sample. In areas of higher rainfall a slightly greater number of species occurred in only one sample (not shown in Table 3). The absence of significant change along traverse may be due to lower mean annual rainfall not having a major impact upon myxomycetes as they are only active after significant rainfall, and the temperature and different tree barks are similar when these organisms are active.

Bark Types

- Bark types with many species recorded, generally yielded most species common in this survey; that is most bark types gave very similar myxomycete species. However some myxomycete species were more restricted in occurrence - *Arcyria cinerea* was found only on 'box' and 'pepper' bark types, *Arcyria sp. H* was found only on 'box', 'mallee' and *Grevillea* bark types, and *Badhamiopsis ainoae* was found only on bark samples from *Acacia* and *Casuarina*).
- Samples of *Eucalyptus camaldulensis* (River Red Gum) were collected because this tree is found over much of eastern Australia, and has potential for determining the geographic extent of particular myxomycete species on a widespread single tree species. Unfortunately, it cannot be used for this purpose, as it proved difficult to obtain dead bark, and the bark obtained yielded few species (no species at one site and only two species at the other site).
- One sample (86A) of *Eucalyptus sideroxylon* (Red Ironbark) was collected (200 km southeast of the other samples) because the bark is very different from the other types collected, being very hard, with about 30% gum. This sample yielded only five species (all members of the Stemonitales). These species occur on the bark of other trees but the balance of the assemblage present is very different.
- The mallee Eucalyptus samples were collected because this tree type is very common in central and southern Australia. On these trees the bark is primarily alive at the surface ('gum' type), and the only dead bark that could be collected were small pieces caught up at branch junctions. For the three samples collected, the number of species per sample was low (4-5), but the species Comatricha anomala and Comatricha pulchella were unusual in the survey.
- The two samples of *Corymbia* (Bloodwood) had thick bark composed of very thin layers, but only two myxomycete species were obtained from one tree and one from the other.
- *Schinus molle* (Pepper tree), although exotic, is widely planted in country towns and around farm homesteads and water tanks, so it could be useful in future surveys. However, the bark yielded low numbers of myxomycete species per sample, and the assemblage was similar in composition to that on most native trees sampled.
- All bark samples were from angiosperms except for the gymnosperm *Callitris* (family Cupressaceae), which yielded an assemblage of bark myxomycetes very similar to that found on angiosperms, with no unusual species.
- Some bark samples were covered by discrete crystals or a thin layer of clay. The crystals are likely to be of salt. The clay layer formed on trees that were in narrow valleys; deposited by water when the tree had been partly submerged. These coverings do not seem to have any effect on the myxomycete growth or the production of fruiting bodies.

In addition to samples of tree bark, moist chamber cultures were prepared with five dung samples, two twig samples and one sample of lianas. The number of identified species found per sample was small, so these substrates are less useful in determining the nature of the myxomycete assemblage than bark samples. The species found on dung were not exceptional, with all the dung species being already known on dung elsewhere in the world (Eliasson & Keller, 1999).

The distribution data from our survey gives several instances where unusual myxomycetes were recorded from adjacent trees at a particular site. *Badhamia macrocarpa* was found at 60A & B, *Didymium clavus* at 860A & B, and *Physarum decipiens* 'heaped eggs' at 62A, B & C and 64B & C. This distribution is consistent with spore clouds/species blooms promoting local concentrations of a species or forms over distances of 100 m or so. This is sometimes observed in field collecting in temperate Australian rain forests, where a single species is very common on many surfaces in a very local area.

The moist chamber method provides quantitative information about species occurrence, variability and productivity, as the sample size put in the dishes is reasonably constant. (In contrast, in the field collection method, samples are related to an unknown amount of substrate material). The number of fruiting bodies at each locality (Table 1) gives a measure of the variability of the fruiting crop among samples. An interesting feature of Table 1 is that the average number of fruitings of a species per sample is generally between 10 and 20. If this was random, then this narrow range seems a little unusual.

Table 3. Myxomycetes recorded from bark samples (from more than one sample). The numbers in the body of the table give an estimate of the number of fruitings found. Tree types are as follows: A, *Acacia*; B, *Eucalyptus* of the box type; C, *Callitris;* Ca, *Casuarina*; Co, *Corymbia*; E, *Exocarpos*; G, *Grevillea*; Ma, *Eucalyptus* of the mallee type; My, *Myoporum*; P, *Schinus*; R, *Eucalyptus camaldulensis*; S, *Eucalyptus sideroxylon.*

sample number	60A	60B	61A	62A	62C	63A	64A	64B	64C	65A	66A	67A	70A	70B	70C	71A	71B	72A	73B	74A	75A	76A	77A	78A	78B	79A	80A	81A	82A	83A	84A	84B	86A	#	#	average #
tree type	B	P	My	Ma	C	My	A	C	B	G	A	Ma	Ma	A	B	B	A	Co	B	B	A	G	B	R	G	B	B	P	C	Ca	Ca	E	S	fruits	sites	fruits/site
Arcyria cinerea	9	1							22							12				39														83	5	17
Arcyria sp. H				118					6	37		5			6	1		71				22												266	8	33
Badhamia macrocarpa	6	33						5																					13					57	4	14
Badhamiopsis ainoae							30				4			7			20													19	39			119	6	20
Calomyxa metalica			8		1		21	1													9		2	1				3	38	12	16	4		116	12	10
Comatricha anomala													24												7								4	35	3	12
Comatricha ellae				21	8		11	20	4	200		26				10	40	70	7		12	20			2	4			6		1		150	612	18	34
Comatricha laxa																	2														1			3	2	2
Comatricha pulchella												12										10												22	2	11
Dianema corticatum								2			9			3		2	1		2	5			2			1	17		5	2	4			55	13	4
Didymium clavus	1	49																																50	2	25
Didymium cf. decipiens						14								1									15		12							1		43	5	9
Didymium dubium					17				2					34	43	2	9		30						12	13		31						193	10	19
Enerthenema papillatum					160					400		10							69		3													642	5	128
Licea biforis									100							30	1		90						21	20		72	80	46	3			463	10	46
Licea kleistobolus	41						1		53					3	2		4				11	3	20		2	5	1		10	3		2		161	15	11
Macbrideola oblonga			3		40		4	10	2		2		1		1		6		2	20				115	20				18	5	4	1		254	17	15
Macbrideola synsporos			1		1			2			1														2		2		3	2				14	8	2
Paradiacheopsis fimbriata										32								1															20	53	3	18
Paradiacheopsis rigida	30							20	10			4								8														72	5	14
Perichaena vermicularis	2				1		9		1		5		14	2	12	76				100		1	1		2				12		17			255	15	17
Physarum decipiens		34	2	70	65	41	3	37	8		7			1	23	15	9			19	4				14	2	10			2	20	51		437	21	21
Physarum leucophaeum					28											100												3						131	3	44
Physarum robustum	192		20		2			67	70		31			21	12		11				7					48			80					561	12	47
Reticularia olivacea	13												1			9																		23	3	8
Stemonitopsis amoena																1				20														21	2	11
Trichia contorta	7			2					20																									29	3	10
number of fruits	301	117	34	211	323	55	79	164	298	669	59	57	40	72	99	258	103	142	200	211	46	56	40	116	94	93	30	109	265	91	105	59	174			
number of species	9	4	5	4	10	2	8	10	13	4	7	5	4	8	7	12	10	3	7	7	6	7	5	3	10	7	4	4	10	9	10	4	4			

Discussion

The main work complementary to the present survey is Davison et al. (2008) for the northern Simpson Desert, 830 km northwest of our study area (Fig. 1). This area has a mean average rainfall of 210 mm, mainly falling during the summer and is similar to the area at the NW limit of our survey, although it is more concentrated in summer and its mean temperature is 2-3 degrees hotter over summer. Davison et al. (2008) sampled 24 localities, obtaining 84 records of 35 species. Excluding *Echinostelium* and most species of *Licea* (not identified in the present study), they had 48 records from 20 sites, with an average of 2.4 records per site. The assemblages recorded in the two surveys are similar as the abundant species are similar, and many of the non-cosmopolitan species of our NSW survey are found in the Simpson Desert. Five of their six species with over three records were all found in our NSW survey, and 7 other species of 1-2 records were also found (see Table 2). Eight of their species were not found in the present survey.

Herbarium collections provide another data set of Australian arid and semi-arid myxomycete sites. Australian herbarium collections are reported in AVH (2015), and both Australian and overseas collections in *Discover Life* (2015) (www.discoverlife.org). As overseas collections are a significant proportion of the known Australian collections, data from the Discover Life (2015) website was used. Collections in these databases come from both bark and other substrates. I have counted on maps in *Discover Life* (2015) (www.discoverlife.org) those sites within the arid and semi-arid area of Australia that are not sites of the Davison et al. (2008) survey. As they are all on, or to the west of, the main highway through Alice Springs in Central Australia they are in the western two thirds of the arid and semi-arid Australia. Table 2 shows the species list largely from Table 1 of this paper, (but with the addition of Comatricha elegans and Didymium squamulosum which were found on both the other surveys), with the number of sites known for each species for the three arid and semi-arid data sets. Many of the species are clearly widespread throughout much of the arid and semi-arid area of Australia, and the data in the table are consistent with there being one assemblage that characteristically occurs over the arid and semi-arid area. However, the information available is very sparse over most of the area.

An important question is the relationship between the assemblage characteristic of the arid and semi-arid zones and those of the adjacent higher rainfall zones. The comparison is difficult to make because all moist chamber culture bark studies in the higher rainfall areas of NSW and Victoria (published and unpublished) have given poor results with few species found per sample. The only published survey of a temperate tree-bark moist chamber assemblages, for a reasonable number of localities (12 localities), is that of Rosing et al. (2007) for eastern Victoria (Fig. 1), with the samples collected in late March. This area (lat 36°04'–37°42'S, long 145°20'–149°21'E) is 400 km due south of the southeast end of our main traverse (sample 60), and the average annual rainfall ranges from 600 to 1500 mm/year. Rosing et al. (2007) looked at the bark substrate at 12 widely scattered localities with an average of 5 species per locality and a total of 36 species. The survey did not define which species were abundant because the number of records is too small. Ten species found in the Victorian survey were found in our NSW survey (Table 2). However, with one exception these 10 species are cosmopolitan and their presence is unremarkable. The Victorian survey did not find most of the more abundant species nor most of the non-cosmopolitan species of our NSW survey.

When the records for arid and semi-arid Australia are compared with the remaining wetter part of Australia (Table 2) using records of herbarium collections reported in *Discover Life* (2015) (www.discoverlife.org), excluding the arid and semi-aid zones, there is confirmation of very different assemblages. The abundant species in the wetter area (*Arcyria cinerea, Comatricha laxa, Cribraria minutissima, Didymium squamulosum*) are not generally abundant in arid and semi-arid Australia, and the non-cosmopolitan species are absent or not abundant indicating the assemblages are very different.

The boundary zone between the assemblages characteristic of the arid and semi-arid and the wetter areas was not determined by our survey. However, there is no reason to expect the boundary to be sharp. Characteristic species of the arid and semi-arid assemblage (e.g., *Arcyria sp. H, Badhamiopsis ainoae, Dianema corticatum, Didymium cf. decipiens, Macbrideola oblonga* and *Physarum robustum*) have a range that extends to the east margin of the survey, so these species must extend past the middle of the semi-arid zone. The cosmopolitan species *Didymium clavus, Cribraria minutissima* and *Macbrideola argenta* were found only on the eastern margin of the survey area, so half way across the semi-arid zone may be the western margin of their range. These observations are consistent with the middle of the assemblage boundary being east of the survey, and probably near the outer margin of the semi-arid zone.

Of the non-cosmopolitan species found in this survey, six are found overseas, mainly in Europe (*Physarum robustum, Macbrideola oblonga, Macbrideola synsporos, Stemonitopsis amoena, Comatricha anomala* and *Comatricha ellae*). None appears to be mainly distributed in North America, so there is a bias to European species. This is attributed to the area generally having winter rain. Superimposed on this there is a tendency for the species to be associated with southern rather than northern parts of both North America and Europe. This is strongly shown in the distribution of *Macbrideola oblonga, Macbrideola synsporos* and *Comatricha anomala*, and weakly shown in *Badhamiopsis ainoae and Dianema corticatum*. This is consistent with the latitude of the survey area (29-33°S) being equivalent to the southern boundary of the United States, and to the south of the southern margin of Western Europe. In summary, the bark assemblage is made up of about half cosmopolitan species, with the other half consisting of species with a distribution in the temperate Northern Hemisphere, or Europe, or southern Europe and the southern United States.

The survey area is in the arid and semi-arid climate classification (http://en.wikipedia.org/wiki/Köppen_climate_classification) of Köppen. It is near the boundary between the hot semi-arid climate (BSh) and the cold semi-arid climate (BSk), and near the boundary between dominant summer rain and dominant winter rain. Similar climates are found elsewhere around the world at a similar latitude and low altitude, mainly in South Africa, NW Argentina, near the Mexico/United States border, and in discontinuous areas between Morocco along the northern margin of Africa to Pakistan. Unfortunately, similar tree-bark moist chamber culture surveys are not yet known for most of these areas.

Overseas, the diversity of myxomycetes in some arid and semi-arid areas is due in part to species found on cacti and other succulents (Lado et al., 2011). Australia has no endemic cacti but has a reasonable proportion of endemic succulents (Kapitany, 2007). These are widely distributed and some are in the arid and semi-arid zones. However, because of their small size and insignificant water-gathering ability, they are likely to be poor substrates for myxomycetes. No suitable succulents were observed in the areas surveyed.

Conclusions

This study used 34 samples to find which myxomycetes species were present in tree bark in arid and semi-arid NSW. The species present and their abundance does not significantly change across the area sampled, and for samples with a reasonable number of myxomycete species there was generally little difference between the tree species. Other bark substrate surveys in arid and semi-arid Australia give a similar species list and abundance. Surveys of bark substrate in wetter areas of Australia give a different species pattern. Generally the more common species in the arid and the semi-arid areas are absent or of low abundance in the wetter areas; they are not cosmopolitan species, and have a world centre of distribution in Europe, or temperate Northern Hemisphere. Generally the more common species in the wetter areas are not common in the arid and semi-arid areas, and these are cosmopolitan species.

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Appendix 1. Sample locations and host material for Myxomycete records in North West NSW

For each sample site (numbers in bold), the following information is listed: sample number, location, latitude, longitude and altitude above sea level. Individual samples at a site are indicated by A, B etc., with sample type (whether bark, dung, twigs or lianas), and the name of the tree, or type of animal producing the dung. The actual field collection number is the given number preceded by 8, so that sample 60A refers to a field sample number of 860A. NP refers to National Park and NR to Nature Reserve. Of the trees only *Schinus molle* is exotic; *Callitris* is the only gymnosperm.

60 Yathong NR, 32° 39.0'S, 145° 39.9'E, 199 m.
60A bark, *Eucalyptus intertexta*, Red box.
60B bark, *Schinus molle*, Pepper tree.
61 Yathong NR, 32° 38.8'S, 145° 39.6'E, 205 m.
61A bark, *Myoporum platycarpum*, Sugarwood.
62 Yathong NR, 32 38.7'S, 145 39.2'E, 344 m.
62A bark, *Eucalyptus socialis*, Red mallee.
62B stem, *Pandorea pandorana*, Wonga vine.
62C bark, *Callitris columellaris*, White cypress pine.
63 Mount Grenfell Historic Site, 31° 17.8'S, 145° 18.8'E, 285 m.
63A bark, *Myoporum platycarpum*, Sugarwood.
64 Mount Grenfell Historic Site, 31° 18.1'S, 145° 18.4'E, 247 m.
64A bark, *Acacia*.
64B bark *Callitris*.
64C bark *Eucalyptus*, box type bark.
64D twigs under *Eucalyptus*.
65 Cobar to Bourke road, 31° 25.2'S, 145° 20.4'E, 199 m.
65A bark, *Grevillea striata*, Beefwood.
66 Gunbooka NP, 30° 38.4'S, 145° 46.1'E, 174 m.
66A bark, *Acacia doratoxylon*, Currawang.
67 Gunbooka NP, 30° 38.4'S, 145° 45.8'E, 171 m.
67A bark, *Eucalyptus socialis*, Red mallee,
67B, dung, kangaroo and goat.
68 Gunbooka NP, 30° 35.1'S, 145° 41.5’E, 214 m.
68A bark, *Corymbia tumescens*, Western bloodwood.
69 Bourke wharf, 30° 05.3'S, 145° 56.1'E, 107 m.
69A bark, *Eucalyptus camaldulensis*, River red gum.
70 30 km E of Wanaaring, 29° 50.2'S, 144° 36.2'E, 106 m.
70A bark, *Eucalyptus socialis*, Red mallee.
70B bark, *Acacia*, tall, rough bark.
70C bark, *Eucalyptus microtheca*, Coolibah.
71 Sturt NP, 29° 18.4'S, 142° 09.3'E, 115 m.
71A bark, *Eucalytus microtheca*, Coolibah, box type bark.
71B bark, *Acacia*, tall with rough zigzag bark.
72 Sturt NP, 29° 25.0'S, 142° 00.0'E, 206 m.
72A bark, *Corymbia terminalis*, bloodwood.

73 Sturt NP, 29° 05.2'S, 141° 13.1'E, 134 m.

73A dung, rabbit, kangaroo.

73B bark, *Eucalyptus coolabah*, Coolabah, box type bark.

74 Road from White Cliffs township to Paroo-Darling NP, 30° 50.5'S, 143° 16.9'E, 124 m.

74A bark, *Eucalyptus microtheca*, Coolibah box type bark.

75 Paroo-Darling NP, 30° 40.0'S, 143° 35.3'E, 79 m.

75A bark, *Acacia*.

75B dung, kangaroo.

76 Paroo-Darling NP, 30° 43.0'S, 143° 30.4'E, 110 m.

76A bark, *Grevillea striata*, Beefwood.

76B twigs of shrubs.

77 Mandalay Homestead to Wilcania road, 31° 12.0'S, 143° 28.9'E, 80 m.

77A bark, *Eucalyptus largiflorens*, Black box.

78 Wilcania town, 31° 33.6'S, 143° 22.6'E, 71 m.

78A bark, *Eucalyptus camaldulensis*, River red gum.

78B bark, *Grevillia robusta*, Silky oak.

79 Wilcania to Menindee Road, 32° 06.9'S, 142° 43.1'E, 73 m.

79A bark, *Eucalyptus largiflorens*, Black box.

80 Near Menindee town, 32° 18.8'S 142° 30.5'E 71 m.

80A bark, *Eucalyptus largiflorens*, Black box.

81 Menindee township, 32° 23.7'S, 142 24.9'E, 62 m.

81A bark, *Schinus molle*, Pepper tree.

82 Menindee to Ivanhoe Road, 32° 27.7'S, 142° 45.0'E, 68 m.

82A bark, *Callitris*, Callitris pine.

82B dung, kangaroo.

83 Menindee to Ivanhoe Road, 32° 28.6'S, 142° 49.6'E, 74 m.

83A bark, *Casuarina cristata*, belah.

84 Ivanhoe to Trida Road, 32° 53.8'S, 144° 39.8'E, 96 m.

84A bark, *Casuarina cristata*, Belah.

84B bark, *Exocarpos aphyllus*, Leafless ballart.

86 Weddin Mountains NP, 33° 54.2'S. 147° 57.8'E, 471 m.

86A bark, *Eucalyptus sideroxylon*, Red Ironbark.

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The vegetation and flora of Strzelecki National Park, Flinders Island, Tasmania

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Abstract: A botanical survey of the vegetation of Strzelecki National Park, on south-western Flinders Island, Tasmania (lat. 40° 13' S; long. 148° 06' E) resulted in 313 vascular plant taxa, being recorded. Of these, 16 are introduced. Of the native flora, 9 are currently considered threatened according to the Tasmanian *Threatened Species Protection Act 1995*. Some of these occur on the calcareous rocks and soils on the western coastal fringe of the Park. There is low species diversity in large areas, for reasons that include extensive ground disturbance by pigs, very high fire frequency in some areas and the depauperate nature of island floras. There were also 137 species of liverworts and mosses recorded for the Park.

Most plant habitats on Flinders Island are represented in the Park. The flora retains an interesting rainforest and wet forest element which shares floristic similarities with rainforest gullies in mainland south-eastern Australia, with the Tasmanian north-eastern highlands, and even with western Tasmania. There are also some affinities with the dry Bass Strait and southern Australian floras.

The pattern and composition of the vegetation is strongly shaped by several factors. Extensive fires have been promoted by fuel accumulation and deliberate burning on the Park perimeter. Topography strongly influences the vegetation (Mt Strzelecki is 756 m high) due to the degree of exposure to strong winds and protection from fire. Cloud capping of the mountain increases the potential moisture available. Wind is a large local factor in vegetation structure. Controls on vegetation at any given site are also responsive to aspect, bedrock depth and other factors.

Eleven vegetation mapping communities are defined, the Park being important for the reservation of several of these. The Park is characterised by the presence of rainfall and evapotranspiration extremes and the vegetation varies accordingly, with rainforest patches in fire protected niches of the mountains and dry heathland on the coastal areas. Strong westerly winds combined with the abruptly rugged mountainous topography have caused some violent localised destruction of forest and scrub canopies by wind.

Key words: mountain vegetation, island flora, fire storms, cloud forests, cloud stripping, steep precipitation gradient, Bass Strait, feral pigs, rainforest, heathland, dry sclerophyll forest, bryophytes, Threatened species.

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Introduction

Strzelecki National Park (lat. 40° 13' S; long. 148° 06' E) is on Flinders Island, one of the Furneaux Group of islands off the northeast of Tasmania (Figure 1). The island is 133,300 ha in area of which 7,631 hectares of very rugged, mainly granite terrain on the south west side makes up the National Park. The Park includes Mt Strzelecki, at 756 m the highest peak on the island and was first proclaimed as a Scenic Reserve under the provisions of the *Crown Lands Act 1911* in August 1935 with an area of 8,500 acres. The original boundary was later realigned on the northern side and additional areas were added on the northeast corner, and the western and southern sides of the Park. Significant areas of Crown land on the eastern and northern sides of the Park were added in 2003. The Park abuts private land on all sides except where it extends to the sea. According to archaeological evidence there had been a hiatus in human occupation of Flinders Island of at least 4,000 years (Sim 1991). Studies of vegetation patterns and fire on Flinders Island are thus of particular interest because it is unusual in an Australian context.

As the National Park was first proclaimed for “scenic” purposes, the most important task for many years was the maintenance of the walking track to the top of the mountain. The first naturalist to climb Mt Strzelecki was, by popular account (Mort 2005), Count Paul Edmund de Strzelecki on 15 January 1842. He was on HMS Beagle, under command of Commander Stokes during the hydrographic survey of the Furneaux Islands. Unfortunately there is no written report of his trip because all Strzelecki’s manuscripts, diaries and letters were destroyed according to his will (Heney 2014). Stokes named the mountain after his Polish explorer passenger (Mort 2005).

There is an account of an ascent by a party from the Victorian Field Naturalists club in 1893 (Gabriel 1894), but otherwise recorded references to the mountain are rare (Willis 1954), until the creation of the Scenic Reserve and the National Park. Until the early 1970s unpublished Tasmanian Parks and Wildlife Service file notes and documents dealt mostly with boundary, acquisition and property questions. After this date there are memoranda showing an increasing preoccupation with Park management issues such as fire management, feral pigs, track maintenance, access, boundary management, and *Phytophthora* infection. In 1974 the Tasmanian Parks and Wildlife Service began to investigate the feral pig problem, in particular their distribution in the Park and evaluated possible methods of pig control. Published information about feral pigs in the Strzelecki Mountains is confined to a brief mention in Statham and Middleton (1987). Unpublished information is found in Underwood (2000) and Saunders and Yockney (2012). Willis (1954) recorded 120 plant species (including 9 aliens) on Mt Strzelecki. Subsequently, plant species lists made by casual visitors between 1976 and 1983 together indicated less than 130 species for the Park. Munks (1990) gives brief vegetation descriptions for her pygmy possum study sites in Fergussons Gully. The Park was sampled during larger state-wide systematic surveys of heathlands (Kirkpatrick and Harris 1999), coastal vegetation (Kirkpatrick and Harris 1995) and wet forests (Wells 1988). A management plan for Strzelecki National Park was approved in 2000 and guides fire, tourism and feral pig management in the Park (Parks and Wildlife Service 2000).

This study area centred on the tallest and most rugged mountains in Bass Strait with their high biodiversity values is an unusual environment which has not been previously comprehensively surveyed. Additionally, the impact of feral pigs in Tasmania is confined to Flinders Island where a range of natural values is impacted. An understanding of feral pig distribution and impacts to vegetation in the Park is important as this information can be used to inform feral pig control or eradication programs, and for conservation and management planning generally. Similarly, the information about the vegetation of the Park can assist in fire management planning as well as providing a basis for interpretation of the Park for tourism purposes.

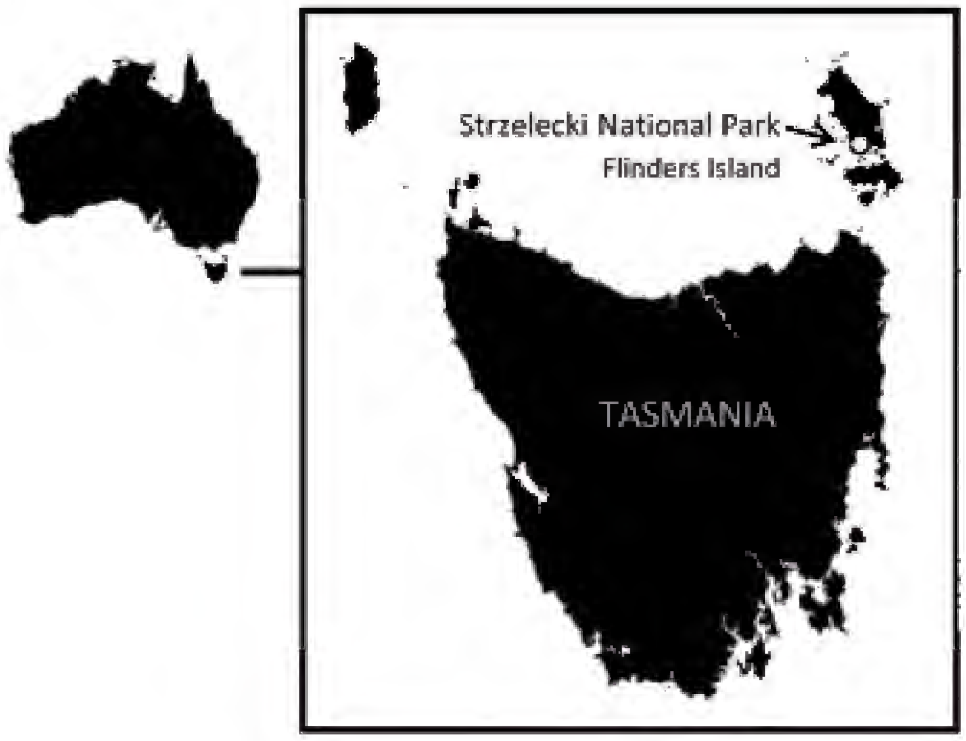

Fig. 1. Locality of the study area in relation to the Australian and Tasmanian mainlands.

Methods

Floristics and vascular vegetation mapping

Vascular plant communities were mapped using a combination of vegetation sampling and aerial photograph interpretation. Mapping began by delimiting vegetation communities on Flinders Island for incorporation into a statewide framework but we considered that a number of communities remained to be satisfactorily resolved in terms of scale and compositional equivalence with statewide mapping units (Harris and Kitchener 2005). We therefore mapped and described communities that were clear to us in the field, subsequently allocating them where possible to nearest equivalent communities in the statewide nomenclature (Table 1). Initially, photo communities were delineated on 1:42,000 black and white aerial photographs and used as a guide to design vegetation sampling.

To pick up the range of vegetation types 179 sample plots each 100 m^2 in area were non-randomly located (GDA94) throughout the Park. Plot locations and photo community boundaries were transferred to the relevant Tasmania 1:25 000 topographic series maps and checked against field observation, field notes and binocular scanning of areas that were not accessed on foot. Vegetation boundaries were subsequently digitised using ArcGIS software and transferred to the Tasmania 1:25,000 topographic map series layer. Fieldwork for plant community mapping took place over three weeks in September and November 1997 and March 1998. Repeated visits by the authors have occurred since and further notes made.

At each plot location the following information was collected: presence/absence of vascular plant species, vegetation structure and notes on slope, aspect, altitude, fire history (evidence of past fire, age/size class structure, fire scarring on trunks, time since last fire), extent and nature of pig damage, degree of fire protection and exposure to onshore winds.

Climate information was gathered from data collected at Bureau of Meteorology accredited stations at Whitemark and Flinders Island airport. Information was also derived from BIOCLIM modelling (Busby 1991) that develops a predictive surface for temperature, precipitation and radiation variables. It is particularly useful for obtaining an indication of rainfall.

Plant species were identified in the field where possible and when there was uncertainty, pressed dried collections were made for subsequent identification and comparison with specimens in the Tasmanian Herbarium. Representative vouchers for as many species as possible were lodged in the Tasmanian Herbarium. Species nomenclature follows Baker and de Salas (2013) except where otherwise indicated.

Bryophyte species presence was recorded in 22, 400 m^2 plots during spring 2004–2006. Plots were located by random placement using DNR Sample Generator Extension v 2.6 (Minnesota Department of Natural Resources) in ArcView to sample a representative range of vascular vegetation types for the Park. A further 84 plots were sampled outside of the Park and within the Flinders bioregion, for the purpose of analysing the association between vascular plant composition and bryophyte composition. All substrate surfaces were searched including soil, rock, logs and the trunks and branches of vascular plants (to a height of 2 m). For identification purposes, a small collection was made for many taxa and voucher specimens prepared where additional reference material was required. Determinations for most samples were made following microscopic examination. Bryophyte species nomenclature follows the Victorian Biodiversity Atlas (2014).

Non-metric Multidimensional Scaling and Analysis of Similarity (Primer v5.2.0) were used to test for significant differences in bryophyte composition between vascular vegetation types.

Fire ageing

Evidence of fires, such as charred stumps, eucalypts stags and even-aged cohorts of obligate seeders such as *Banksia marginata* can be observed throughout the Park. Evidence of fire frequency can also be assessed from the distribution of vegetation types and associated species composition. Observations were made on the degree of natural fire protection, whether filmy ferns (*Hymenophyllum* species and *Crepidomanes venosum*) were present or not (Brown and Podger 1982), size classes, nodal counts on banksias, presence or absence of eucalypts, fire boundaries, fire scars on trees, presence and vigour of post-fire adventive species, proportions of burned and unburned trunk of *Dicksonia antarctica* and *Xanthorrhoea australis*.

Fire ageing was estimated usually by nodal counts on *Banksia marginata* and recorded as the average of a few counts from several individuals at any one site. This method is recognised as indicative only. In a small number of cases, *Leptospermum* species were sectioned for growth ring counts. Visual estimations of eucalypt age were also done in the field, using as a guide, diameter against ring counts of some eucalypts cut down outside the Park.

Empirical field evidence of fire was cross referenced with Parks and Wildlife Service files, conversations with local residents, Parks and Wildlife Service Rangers, old newspaper reports and Tasmanian State Archives documents. There has been no fire in the core of the Park between 1997 and 2015.

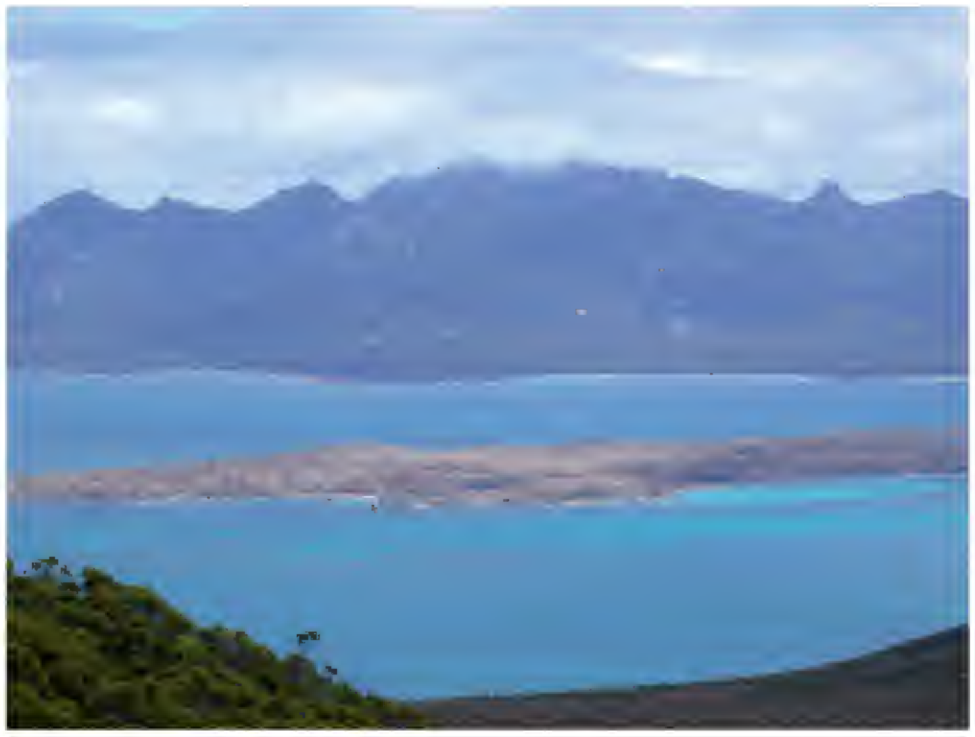

Fig. 2. Strzelecki National Park looking from the south across Armstrong Channel.

Results

Geology

Strzelecki National Park exhibits some of the most rugged granitic topography in Australia (Figure 2). The basement rocks are Devonian granodiorites which are intersected by faults and numerous joint sets (Jennings and Cox 1978). The creeks follow major zones of weakness. Although the lithology is uniform, the structural geology is varied, giving rise to numerous landforms which have a bearing on vegetation history, and fire protection. Landforms characteristic of granite landscapes abound and include: tors, tafoni, sheet structures, gnamma and rillen. The Trousers

Point aeolian calcarenite (Figure 3) is probably of Tertiary age and has weathered to produce highly calcareous soils (typically pH 7.5).

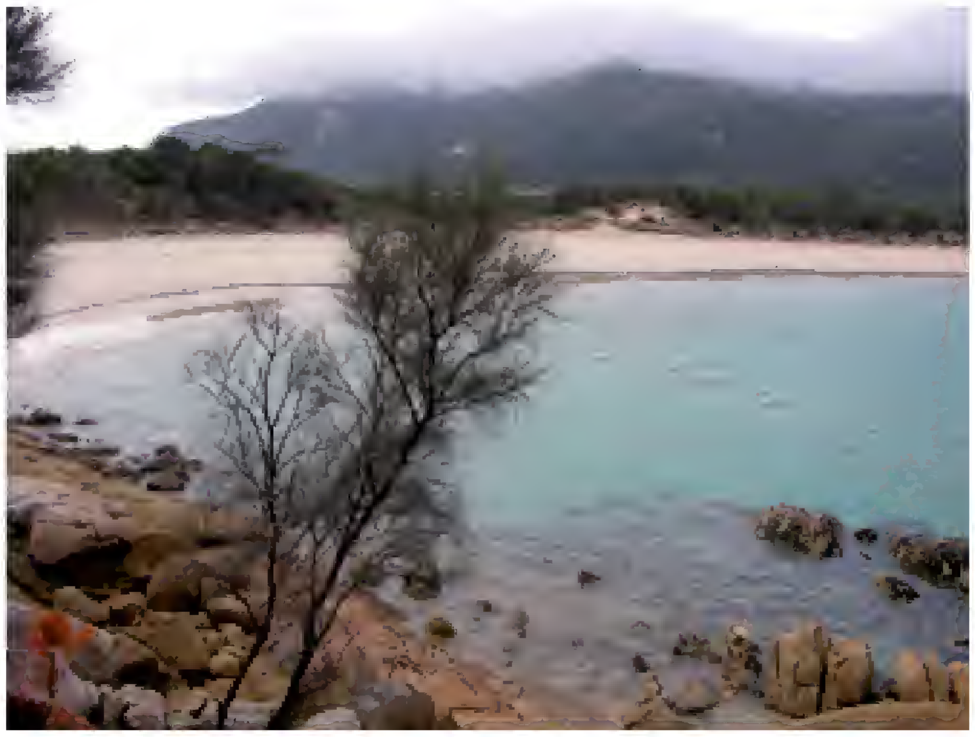

Fig. 3. Trousers Point is bounded variously by sandy, granite and calcarenite coast.

Climate

The nearest climatic record stations are at Whitemark Post Office and Flinders Island Airport, only 8 km and 11 km away respectively, but in a notably different environment to that experienced in the mountains.

Rainfall

Rainfall modelling shows a predicted 1490 mm annual average in the mountains, with reduced evapotranspiration because of the frequent cloud cover and mist, to the coastal area at Trousers Point where the predicted annual average is as low as 468 mm and the limestone bedrock does not retain groundwater.

Winds

The prevailing winds over most of Tasmania are north-west to south-west with greatest strength and persistence in winter. On Flinders Island the greatest wind strength is actually in spring–summer, particularly September to January and is also most persistent from November to April. The annual average monthly maximum wind speed is fairly even throughout the Spring and Summer at 25–30 km/hr and in April–July the wind drops to between 20 and 25 km/hr. Average maxima are fairly similar throughout the year but gusts up to 131 km/hr have been recorded for October (Bureau of Meteorology http://www.bom.gov.au/climate/data/index. Accessed 3 August 2014). Winds have an unbroken fetch from the west.

Above the maximum friction layer at sea level, the Strzelecki massif is buffeted by the higher speed upper layer air stream. As the air rises to blow over the mountain top it is constricted between the summit below and the air layers above and when compressed in this way its speed increases until it passes the summit. As well as horizontal compression, there will be lateral constriction of the air stream as it is funnelled between and around peaks. There are recorded speeds of winds reaching 360 km/hr over mountain tops in the United States (Critchfield 1966). Thus it would be expected that very strong gusts would be more prevalent in the peaks, in addition to turbulence generated by the rugged topography. Once the winds from the south-east to the SW exceeds 35 km/hr at sea level, clouds will form on the Strzelecki Peaks and a cloud cap is present on 30–40% of days of the year (James Luddington pers. comm.).

Temperature

The temperature regime recorded at Flinders Island airport and Whitemark (together with the rainfall pattern) is typical of a Mediterranean climate (Cody 1986), that is, with warm summers 20–25°C monthly means and cool winters (<15°C) in which frosts are rare. The temperatures high in the Strzelecki Mountains will be depressed due both to the adiabatic lapse rate and the cooling westerly winds.

The figures at the lowland coastal station at Flinders Island Airport cannot be expected to reflect the climatic conditions on the Strzelecki Peaks. This applies to such measures as rainfall, temperature, cloud cover, maximum wind gust and mean number of days of strong wind. The Strzelecki Peaks rise to 750 m, a large massif directly in the path of the persistent winds, the rugged topography causing turbulence as the prevailing air stream moves eastward over the peaks, rising rapidly, cooling and causing orographic cloud cover for many days of the year. Clouds also form from warm humid easterly air masses moving from the Tasman Sea and being intercepted by the mountain. Sometimes when this occurs the tongues of mist pour over the summit and stream down the western side of the mountain.

Soils

Soils over most of the study area are acid (typically pH 3.5), skeletal, grey sandy loams or gravelly sands depending on microtopography. Deeper soils occur in the gullies and the few flat areas. The depth of the organic horizon varies, and time since last fire, together with vegetation type determine this. The soils on the limestone on Trousers point are distinctly different being friable, calcareous alkaline sands (typically pH 7.5–8).

Flora and Vegetation

There are 313 vascular plant taxa from 85 genera and 137 taxa of non-vascular plants from 55 genera (20 liverworts genera, 35 moss genera) represented in the Park (see Appendix 1). Sixteen vascular plant taxa are exotics which have penetrated edges from cleared boundaries. These are ubiquitous wind-borne weeds such as *Hypochaeris radicata* which occur on fire breaks and tracks, and the "human camp followers' such as *Cerastium* species which occur around the heavy use area at the picnic site at Trousers Point. Shoreline weeds include cosmopolitan herbs such as *Plantago coronopus* and *Cakile maritima*, which exhibits a distribution from far eastern Victoria to Flinders Island. Within the core of the Park, weeds are extremely rare. A thistle was observed growing in a valley just south of the head of Big Hollow, perhaps resulting from a chance wind-blown or mammal-borne seed. The native shrub, *Zieria arborescens* is frequent throughout the Park and behaves in a 'weedy' manner because it thrives as a result of ground disturbance by pigs. The introduction of exotic species into such disturbance environments would be unfortunate because they would be encouraged to persist by frequent ground disturbance.

There are 17 vascular taxa that are considered endemic in Tasmania. These are mostly species which are widespread and common on the Tasmanian mainland. There are 9 taxa which are listed on the schedules to the Tasmanian *Threatened species Protection Act 1995*. Of these, at least *Eutaxia microphylla* and *Myoporum parviflorum* are confined in the Park to the coastal limestone or calcarenite on Trousers Point. These species have been discussed by Underwood (1998) and Harris *et al*. (2001). No bryophyte species within the Park has been determined as threatened in a statutory sense, however the moss *Calomnion complanatum* was assessed under IUCN criteria by Scott *et al.* (1997) who considered this species to be endangered within Australia.

Table 1. Mapping units and communities discussed in this paper and their relationship to the Tasmanian statewide TASVEG mapping units (Harris and Kitchener 2005).

Communities discussed in this paper	TASVEG mapping units (Harris & Kitchener (2005)
Coastal Vegetation	Coastal heathland (SHC)
Coastal Vegetation	Heathland on calcarenite (SCH)
Mountain and Peak Complex	Lichen lithosere (ORO)
Melaleuca ericifolia Forest (NME)	*Melaleuca ericifolia* forest (NME)
Eucalyptus viminalis Forest	*Eucalyptus viminalis* Furneaux forest (DVF)
Eucalyptus viminalis Forest	*Eucalyptus viminalis* grassy forest and woodland (DVG)
Eucalyptus nitida Forest	*Eucalyptus nitida* Furneaux forest DNF)
Eucalyptus globulus - *Allocasuarina verticillata*-*Callitris rhomboidea* forest.	*Leptospermum* forest (NLE)
Myrtaceous scrub	Dry scrub (SDU)
Myrtaceous scrub	Heathland on granite (SHG)
Myrtaceous scrub	Regenerating cleared land (FRG)
Allocasuarina verticillata Forest	*Allocasuarina verticillata* forest (NAV)
Spyridium gunnii - *Pomaderris apetala* Cloud Forest	Broad- leaf scrub (SBR)
Zieria arborescens - *Olearia lirata* shrubland.	Broad-leaf scrub (SBR)
Leptospermum lanigerum low forest	*Leptospermum* forest (NLE)
(not described here; very localised)	*Acacia melanoxylon* forest on rises (NAR)

The vegetation can be divided into 11 mapping units which are represented by distinct structural and floristic attributes on the ground (Table 1, Figure 4). Each of these types and their associated communities are described in more detail below. The mapping units follow Harris and Kitchener (2005) but the vegetation communities we describe in the paper do not always have a one to one relationship as we found it convenient to describe what appeared to us to be distinctive facies. Table 1 shows the relationship of the statewide mapping units and the communities we describe here.

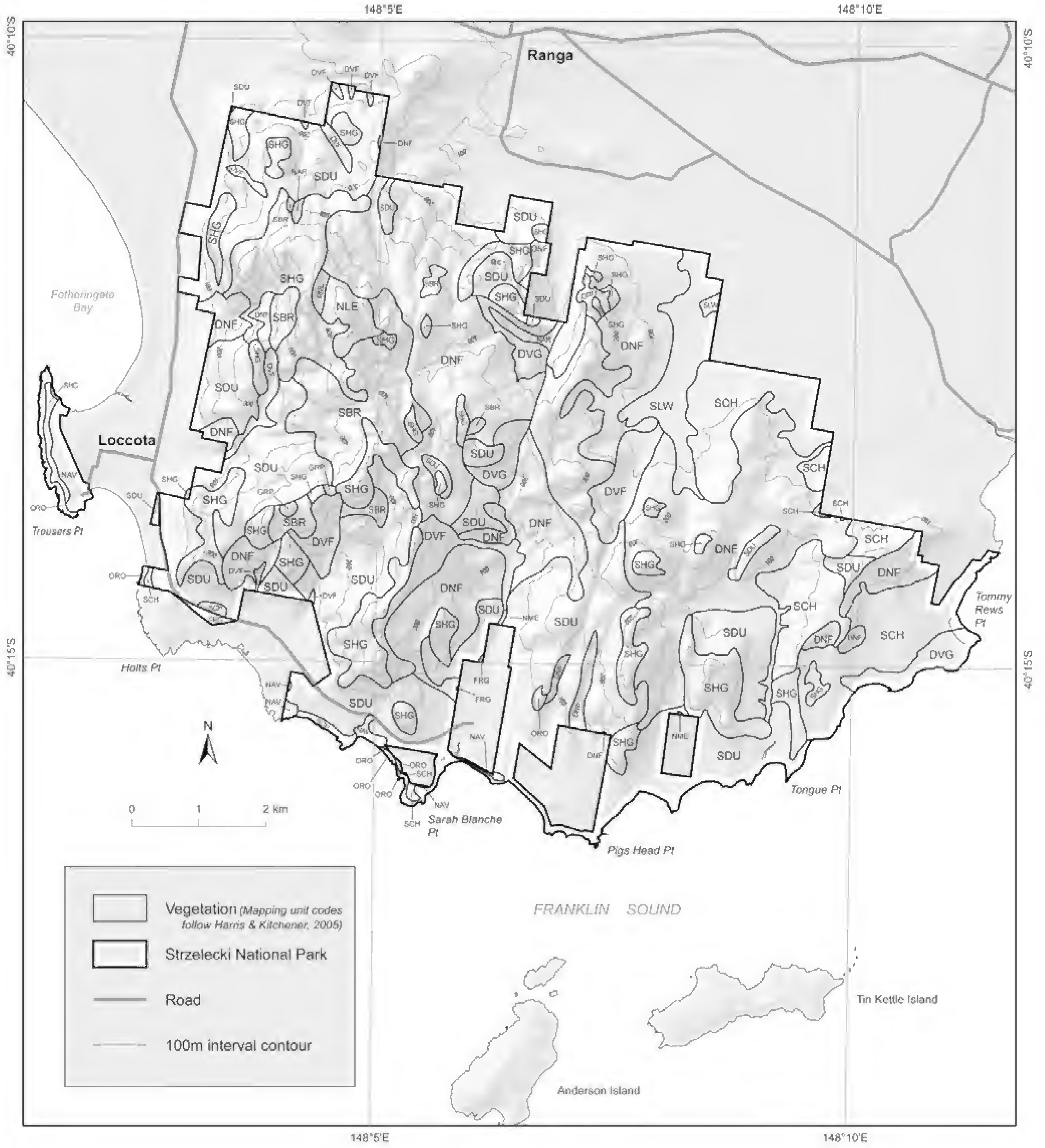

Fig. 4. The vegetation of Strzelecki National Park, Flinders Island. Vegetation types follow Harris and Kitchener (2005).

Coastal Vegetation

The area mapped as coastal vegetation occupies a narrow zone because the hinterland vegetation has fully developed right to the coast. Very high fire frequencies can reduce the stature of vegetation to heath or grassland and allow greater influence by maritime factors such as salt spray further inland. The coastal zone is therefore narrow and divisible into two main types: granite communities and calcarenite communities.

There are many places on the granite where *Allocasuarina verticillata* Forest comes right to the rocky shore and where exposure is not as great, there is no reduction in structure. The usual granite coast zonation on is found here with *Disphyma crassifolium, Apium prostratum* and *Sarcocornia quinqueflora* found in the rocky zone. Windrowed heath is common on the western shore. At Trousers Point wind had gained access through a natural wind funnel. Here there is a marked transverse zonation comprising *Allocasuarina* flanked by low wind pruned *Kunzea ambigua* shrubs in between these flanks being a corridor of *Austrostipa stipoides*. On a shallow depression at the core of this wind funnel is a low grassy herbfield dominated by *Microlaena stipoides* and comprising mainly *Eryngium vesiculosum*, *Drosera pygmaea*, *Distichlis disticophylla*, *Lobelia anceps*, *Selliera radicans* and *Oxalis perennans*. *Ficinia nodosa* emerges from this herbfield.

Mountain and Peak Complex.

All of the "bare rock" falls into this complex which comprises four identifiable communities: Lichenfields, *Xerochrysum* Herbfield, *Lepidosperma elatius* Sedgeland and Sparse Mountaintop Heath.

Lichenfields are apparent where bedrock is visible in cliffs, boulder fields, talus slopes, tors and sheet structures. Freshly exposed rock is extremely rare. The dominant lichen species covering these rocks include *Cladia* species (a lichen inventory was beyond the scope of this paper). Few vascular plants are recorded on these areas but in gnamma pits where there may be a small accumulation of gravel there is usually a collection of the following: *Centrolepis strigosa*, *Crassula sieberiana*, *Acianthus* sp., *Drosera auriculata* and *Calandrinia calyptrata*. In rillen, there may be mainly bare water-stained rock with some lichens and bryophytes. While lichens occupy almost 100% of the area of sheet structures, bryophytes are found in depressions and on the perimeters of sheets. The bryophyte patches are often more extensively developed on the upper perimeter of sheets fed by moisture draining through the layers of vegetation above. *Xerochrysum papillosum* is a common understorey component in the mountains but in some rare situations, it dominates small floriferous herbfields, for example one on a shelf with a south-westerly aspect just east of Lovetts Peak. Here, shrubs of *Tasmannia lanceolata* and clumps of *Lepidosperma elatius* up to 1–1.5 m high are scattered through a grassy herbfield with species of *Agrostis, Gnaphalium* s.l., *Rytidosperma, Viola, Crassula, Tetrarrhena disticophylla* and *Centrolepis strigosa*. This area appears to be highly exposed to wind as well as occurring in the cloud forest zone. It is possible that the site could support an elfin forest and the small *Tasmannia* shrubs may be the pioneers of the community here. The reason for the absence of such a forest may be that the site was burnt in a past fire and succession has been extremely slow because of such a high exposure and the slow growth rates due to low insolation and cooler temperatures.

Lepidosperma elatius or *Gahnia* Sedgeland is a rare community occurring only in a few sites where the areas occupy no more than 0.25 ha (too small to map separately). One notable patch occurs on a saddle west of Mt Belstead and is conspicuous from a light aircraft. In some areas *Gahnia grandis* dominates patches at higher altitudes where fire has made incursions into *Leptospermum* Forest. The *Gahnia* forms such dense swards that other species would be precluded from growing, until the *Gahnia* nears the end of its life span.

Melaleuca ericifolia Forest

Melaleuca ericifolia is a common component of riparian vegetation along the major creeks, forming thickets in basins where there are deeper soils but the best extent of *Melaleuca ericifolia* forest is on the lower reaches of Big River. The forest straddles the boundary with private land and there has obviously been some history of disturbance from stock and feral pigs.

The forest on Big River is more or less even aged (with a 20 cm median diameter at breast height in a sampled *Melaleuca* stand. The co-dominant is *Acacia melanoxylon*. There is a canopy cover of >95% but some open patches occur, perhaps where wind has entered and broken some trees. A sparse shrub layer comprises rare scattered 8 m high *Pomaderris apetala*. There are 3–4 m high patches of *Zieria arborescens* and the ground layer comprises *Hypolepis rugosula, Carex appressa* and juvenile *Melaleuca ericifolia*.

There is a lot of litter but a great deal of bare ground. Pigs have ploughed the deep alluvial soil, pushing litter into heaps and the plants surviving are clearly only those capable of withstanding massive and prolonged ground disturbance. There may have been more species diversity in the understorey in the absence of pigs. *Blechnum nudum* and carpets of bryophytes occur only under the lip of the stream bank inaccessible to pig disturbance. Occasional plants include *Pteris tremula*, *Galium* sp., *Pellaea falcata*, *Cyathea australis, Callitriche ?stagnalis* and *Isolepis* sp.

Eucalyptus viminalis Forest

Such forests are not extensive and are best developed on the south-eastern slopes under Mt. Razorback and in some of the larger gullies such as Bob Smiths and Fergussons gullies. *Eucalyptus viminalis* rarely occurs above 450 m asl.

Understorey species associated with *Eucalyptus viminalis* varies according to the site type. In the gullies of Bob Smith and Fergussons, there is a subdominant layer of *Olearia argophylla, Cyathea australis, Elaeocarpus reticulatus* and *Pomaderris apetala*. Sometimes *Eucalyptus viminalis* co-occurs with *Eucalyptus globulus,* e.g. in Costers Gully (where *Callitris rhomboidea* also occurs). It is likely that *Eucalyptus viminalis* together with *Eucalyptus globulus* was a major component of forests on the alkaline soils north of the Park now been cleared for farmland. This is judged from a remnant on private property on the north-western boundary.

In the southeast of the Park there is *Eucalyptus viminalis* grassy forest and woodland (DVG) where frequent low intensity fires have opened up the understorey layer and suppressed any development of a shrub layer.

Eucalyptus nitida Forest

This forest type is extensive and the most widely distributed community in the Park. It is especially abundant on the slopes of the mountain peaks but rare on the coast and on the limestone soils. The vegetation dominated by *Eucalyptus nitida* ranges from 5–6 m scrub, where the eucalypt is emergent over other co-dominants such as *Leptospermum scoparium, Kunzea ambigua, Acacia verticillata, Pomaderris apetala* and *Allocasuarina monilifera* to older (taller) forest (16–20 m) with a tall shrub layer at 8–9 m often of *Acacia mucronata*. At one site, *Eucalyptus nitida* was emergent at 20 m over an *Acacia melanoxylon-Eucalyptus nitida* sub-canopy at 15 m. In some localities, *Eucalyptus nitida* forms a uniformly 10–12 m tall forest with no co-dominants whereas at other sites it is co-dominant with *Eucalyptus globulus* in forests of 12–20 m tall. *Eucalyptus nitida* co-occurs with *Eucalyptus viminalis* in damp fire-protected sites high in the mountains (e.g. 270 m above sea level). Scrubs as low as 4–5 m were sampled; the tallest forest was 22 m high.

Eucalyptus nitida is most prevalent on the flanks of the mountains and ridges, rarely occurring on the summits or above the boulder fields; in the core of the range there are large eucalypt-free areas. There are clearly even-aged cohorts of eucalypts corresponding to major fires.

The range of floristic variation within the *Eucalyptus nitida* communities is large and reflects various site factors such as drainage, relative protection from feral pigs and aspect (and therefore moisture availability). Apart from the common shrub layer dominants mentioned above, the most common species are the ubiquitous *Zieria arborescens* and *Lepidosperma elatius*. Some moister sites contain filmy ferns on bryophyte-covered boulders and tree ferns. A variety of other ferns may be present including *Polystichum proliferum, Asplenium obtusatum, Ctenopteris heterophylla*, and *Hypolepis rugosula*. Other shrubs commonly include *Banksia marginata, Leptospermum glaucescens, Leptospermum scoparium, Hakea teretifolia*, and *Coprosma quadrifida*. Forbs and graminoids include *Ehrharta disticophylla, Hydrocotyle hirta, Xerochrysum papillosum* and *Viola hederacea*. In the well-drained gravelly acid sands near the coast, ground flora diversity is much higher.

Eucalyptus globulus-Allocasuarina verticillata-Callitris rhomboidea Forest

This distinctive community occurs mainly on the western parts of the range at lower altitudes, on the lower to mid slopes. It ranges from scrub of 2.5 m to forests 18 m tall; most of the sampled forests fall within the 8–11 m height range. *Eucalyptus globulus* is often emergent over other species but occasionally is co-dominant with *Eucalyptus nitida, Callitris rhomboidea, Allocasuarina verticillata, Eucalyptus viminalis* or *Acacia melanoxylon*. There is often a shrub layer which may be sparse or patchily dense at 2 m or 4–6 m. The shrub layer often includes younger specimens of the dominant trees. Other shrub species which are common include *Leptospermum scoparium, Acacia mucronata* and *Kunzea ambigua*. The climbers *Clematis microphylla, Clematis aristata* and *Cassytha melantha* are often present.

The ground layer typically includes *Hydrocotyle hirta, Lepidosperma elatius, Poranthera microphylla, Dianella revoluta, Pultenaea daphnoides* and *Epacris impressa*. Understorey floristic diversity varies according to variety of microhabitats present. For example, where *Eucalyptus globulus* is emergent over dense scrub, there are few vascular plant species, whereas on a slope where there may be breaks in the canopy together with boulders and rock slabs on the ground there will be more species. The dominants of this community are drought-tolerant and the associated understorey species are likely to exhibit similar characteristics. The community does not occur higher in the cloud zone, nor in deep shaded gullies. It typifies the slopes on the western flanks of the granite mountains where soil may be shallow, indeed often exposing slabs of granite and where they are exposed to the full force of the desiccating westerly winds.

Myrtaceous Scrub.

Myrtaceous scrub is best developed around the perimeter of the Park, especially along Big River Road and near the northern perimeter of the Park. These scrubs are dominated by varying combinations of a few species, mainly *Allocasuarina verticillata, Allocasuarina monilifera, Banksia marginata, Leptospermum scoparium, Acacia verticillata, Leptospermum glaucescens, Monotoca glauca, Kunzea ambigua* and *Eucalyptus nitida*. The vegetation is very dense and is likely to have resulted from fires 28 to 35 years prior to the survey.

Kunzea ambigua was a colonising pioneer on the paddocks at the Big River property that were regenerating to scrub. This area is mapped as Regenerating Cleared Land (FRG).

Low understorey species diversity is evident and some species may only occur in the soil seed bank at a site. This vegetation is highly flammable, in some cases ladder fuels, including *Gahnia grandis* being present. Other common understorey species include *Cassytha melantha, Lepidosperma concavum* and *Lepidosperma elatius*. There is a marked dichotomy in myrtaceous scrubs. Those described above are at lower altitude. Above 700 m in the cloud forest zone there is more protection from high fire frequency; the *Leptospermum* is more gnarled, *Dicksonia antarctica* is sometimes present in the understorey and other species include *Histiopteris incisa, Rumohra adiantiformis, Hymenophyllum rarum, Grammitis* sp., *Juncus pauciflorus, Huperzia varia,* and *Microsorum pustulatum*. The prevalence of filmy ferns in the understorey of a tea tree scrub seems paradoxical but at higher altitude sites there is both the moisture availability as well as the fire protection to support their persistence.

Allocasuarina verticillata Forest

This vegetation type is not extensive in the Park but reaches its best development on the exposed western shore, on Trousers Point, on the driest aspects on the granite slopes above the western coastal plain, and on some slopes above the Big River homestead.

These forests are mostly dense stands which appear even-aged, generated from particular fire events. In the sampled forests are three clusters of heights (3–5.5 m, 8–11 m and 13–14.5 m) - these heights could represent different age cohorts from different fires. Mostly the stands are dominated solely by *Allocasuarina verticillata* but occasionally there is *Eucalyptus nitida* or *Eucalyptus globulus*, or *Leptospermum laevigatum*. There is a sparse shrubby understorey at 2–3(–6) m but often the understorey is absent as the canopy closes out. Herbs and shrubs may be rare and scattered. For example at Trousers Point when originally surveyed in 1997 the forest there was then described as having a dense 100% litter layer of needles and branchlets from the sheoak. Rare *Myoporum insulare* about 0.6 m occurs. Other scattered vascular species include *Pimelea serpyllifolia*, *Lysimachia arvensis, Dichondra repens, Clematis microphylla, Trifolium repens, Microlaena stipoides*, *Ajuga australis* and *Rhagodia candolleana*. *Xerochrysum papillosum* has mostly died out. *Beyeria viscosa* is present only in the protection of the cage formed by a fallen branch. Where gaps occur through disturbance such as tree-fall, wind throw or otherwise, the species diversity of these forests becomes apparent. Many of the species clearly require disturbance for regeneration. Following the construction of a road along Trousers Point towards Fotheringate Bay, many species appeared, including: *Apalochlamys spectabilis, Solanum laciniatum, Xerochrysum papillosum, Oxalis perennans, Dichondra repens, Muehlenbeckia australis, Beyeria viscosa, Cirsium vulgare*, *Acaena novae-zelandiae, Pimelea serpyllifolia, Microlaeana stipoides, Trifolium repens, Pelargonium australe*, *Stackhousia monogyna, Gnaphalium* s.l. sp., *Centrolepis* sp., *Crassula sieberiana, Pimelea curviflora* and *Olearia ramulosa*. About 300 m further south a shrubby area in a wind-throw gap contains many of the same species with an extra six species including *Rytidosperma penicillatum* and *Parietaria debilis*, the latter species growing on a granite ledge under litter.

In 2012 violent winds struck the coast in the vicinity and destroyed the canopy of the forest described above, initiating germination of many shrubs in the understorey as well.

Some of the tallest *Allocasuarina verticillata* occurs 2 km to the north and inland of the mouth of the Big River. Although the site is on private land just outside the Park boundary it is described here because it has a wind throw patch about 10 m diameter. Many disturbance species are emerging including *Goodia lotifolia, Hypolepis rugosula* and *Solanum laciniatum*. The diameter at breast height of the largest sheoaks is 48–49 cm at the time of survey.

Spyridium gunnii-Pomaderris apetala Cloud Forest.

This community was sampled at sites between 510 and 680 m around the higher peaks of the Park where there is frequent and often persistent cloud cover resulting from the orographic effect in intercepting the westerly air stream. The community is generally well fire protected because of large boulder fields. In fact the best development of these distinctive forests occurs high around the headwaters of the major creeks in the western part of the Park where mist is first intercepted by being funnelled up the gullies. Huge boulder fields are prevalent in the upper reaches of major creeks like Fotheringate Creek, resulting from topples of weathering remnant granite tor stones. These provide good fire protection (Figure 5). There is evidence that large eucalypts occurred in such sites because on the eastern slope of Lovett Peak above the saddle amidst *Pomaderris apetala - Spyridium gunnii* low forest, there was a large (100 cm dbh), charred fallen eucalypt. Similarly on a saddle northwest of Mt Strzelecki (altitude 520 m) amongst a gully boulder field of *Olearia argophylla - Pomaderris apetala* low forest with a broken crown, there was a large dead eucalypt downer (fallen limb or tree trunk) which was 110 cm dbh but appeared to be only 6–8 m to the first branch. It is possible these eucalypts may have toppled in from adjacent ridges above their present resting places. *Atherosperma moschatum* also occurs in this community.

The community has a high diversity of species in the understorey, including many ferns and bryophytes. Typical species in the shrub layer include *Olearia phlogopappa, Zieria arborescens*, *Olearia lirata, Tasmannia lanceolata* and *Acacia melanoxylon*. A typical sample plot would contain, as well as the above: *Histiopteris incisa, Xerochrysum papillosum, Microsorum pustulatum, Asplenium appendiculatum, Hypolepis rugosula, Hymenophyllum cupressiforme, Cyathodes juniperina, Polystichum proliferum, Ctenopteris heterophylla, Dicksonia antarctica, Coprosma quadrifida, Asplenium flabellifolium* and *Parsonsia brownii*.

Amidst the boulders there is abundant shady protected habitat for ferns, bryophytes and lichens. Many plants grow in skeletal humic soils on tops of large boulders with some trees growing up between boulders.

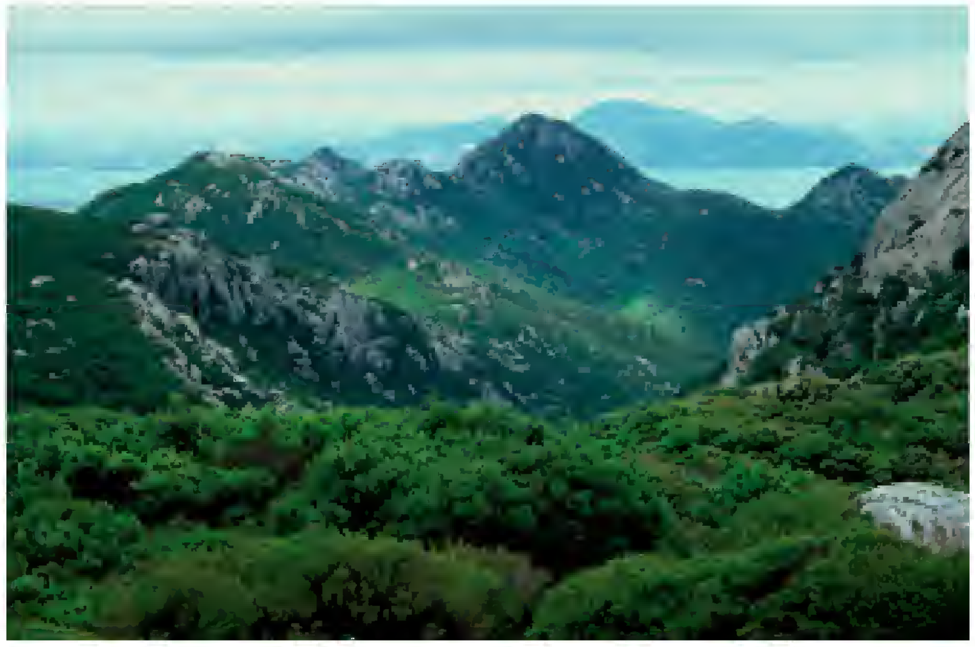

Fig. 5. Looking over the valley of Fotheringate Creek towards the south-east.

Zieria arborescens-Olearia lirata Shrubland

This is a disturbance disclimax community which is more extensive in some parts of the central and eastern parts of the Park. The shrublands are variously dominated by *Zieria arborescens* which is almost ubiquitous, *Olearia lirata, Pomaderris apetala, Acacia verticillata* and *Olearia argophylla*. *Lepidosperma elatius* is mostly prevalent in the understorey. Canopy cover is usually 85–95%. A typical site occurs at, at 460 m altitude on the upper reaches of Fotheringate Creek where it first swings to the westward. On the slopes above the creek is an extensive field of dense scrub dominated by *Zieria arborescens* and other species. Emergent over the scrub are some large eucalypt stags presumably burnt by the same fire which instigated the present shrubby regrowth. *Olearia lirata, Olearia argophylla* and *Zieria arborescens* dominate the shrubland and *Lepidosperma* is tall and dense in the understorey. Specimens of *Dicksonia antarctica* survive, especially down toward the creek. Canopy cover is 90% and while species diversity through the patch is low, there is an increase in diversity towards the margins near the creek where relicts of rainforest or mixed forest occur: *Atherosperma moschatum*, *Dicksonia antarctica* and other ferns including filmy ferns.

The facility of *Olearia lirata* and *Zieria arborescens* as colonisers of disturbance sites is illustrated at a site on the slopes above the creek on the upper reaches of Big River at 290 m asl. Here, a landslip zone has been colonised mainly by two species *Olearia lirata* and *Zieria arborescens.* There is a dense mat of grasses and other herbs on the moist ground. The shrubs are now 2–3 m tall while the scrub to the edge of the slip is dominated by *Pomaderris apetala* and is 5–6 m in height. The age of the slip is unknown. *Zieria arborescens* is one of the most abundant shrubs in the reserve and continuous regeneration is evident in many places. The persistence and success of *Zieria* at least, and possibly *Olearia lirata* must be facilitated by feral pig disturbance.

Leptospermum lanigerum Low Forest.

This disturbance community (sampled at five sites between 660 m and 710 m asl) appears to have been long unburnt and comprises a dense forest of umbrageous multi-stem *Leptospermum lanigerum* with a very open understorey characterised by a dense bryophyte and fern carpet. *Monotoca glauca* occasionally occurs as an undershrub and *Dicksonia antarctica* occurs more abundantly along the drainage lines. Bryophyte cover in most parts of the forest is complete and growing from this substrate we observed *Polystichum proliferum*, juvenile *Tasmannia lanceolata*, *Hypolepis rugosula, Histiopteris incisa, Xerochrysum papillosa, Juncus pauciflorus*, juvenile *Coprosma quadrifida, Hydrocotyle* sp., *Uncinia* sp., and juvenile *Cyathodes juniperina*. *Huperzia varia* was occasionally observed growing in the forks of branches on *Leptospermum*. Occasional specimens of *Tasmannia lanceolata* occur in the tree canopy. Some of the above species such as *Histiopteris* and *Xerochrysum* indicate some level of disturbance here but the presence of occasional plants of *Gahnia grandis* which are clearly losing vigour and are approaching death, probably represents the decline of this adventive species from the major fire event that probably triggered germination of the *Leptospermum* forest. In some sites in this forest there are *Epacris paludosa* shrubs with stems 3 m long and basal diameters of 5 cm. At the head of the gully at 660 m amidst 4 m high *Leptospermum lanigerum* there is a solitary contorted multi-stem *Eucalyptus nitida* with dense lichen encrustations on the limbs. Is this analogous to the position of eucalypts in the "dry rainforest" of the pre-Holocene landscape?

Bryophyte association with vegetation mapping units

The eastern Bass Strait climate, with enduring dry windy conditions, ensures that the majority of lower elevation vegetation types are unsuitable for luxuriant bryophyte growth. Only the most desiccation tolerant species are common in coastal dry vegetation and these sites generally include a smaller subset of the Park's bryoflora. Sites that are protected from drying winds yield higher bryophyte richness. Gullies and riparian areas provide conditions more favourable for bryophyte richness compared with surrounding areas (Pharo and Beattie 2001; Dynesius *et al*. 2009), and this is pronounced within the Park. The peak of Mt Strzelecki and high elevation cloud forest provides for high species richness due to lower temperature and higher humidity on average compared with the remainder of the Park (Figure 6).

Within the Flinders bioregion in Tasmania, the contrast in bryophyte composition between cool humid habitats and dry lowland habitats contributes to an overall significant association between bryophyte and vascular plant composition (ANOSIM: Global R=0.52, $p<0.001$) (Figure 7). The association, while significant, is only moderate due to a subset of species which occupy similar habitats within a range of dry woodland and scrub communities.

Coastal Vegetation on alkaline sands has a characteristic bryoflora including *Trichostomum eckelianum*, *Tortula antarctica*, *Thuidiopsis furfurosa* and *Rosulabryum billardieri*. The Tasmanian distribution of *Trichostomum eckelianum* appears restricted to the Furneaux Islands (AVH 2014). On bark and logs, the mosses *Racopilum cuspidigerum* var. *convolutaceum* and *Sematophyllum homomallum* are frequently occurring, as is the widespread liverwort *Chiloscyphus semiteres* s.l. In *Allocasuarina verticillata* Forest, bryophytes have very low cover and richness on the ground where the mosses *Gigaspermum repens*, *Trichostomum eckelianum*, *Barbula calycina* and *Tortula antarctica* occur in patches. On acidic, peaty sand the characteristic liverworts *Lethocolea pansa*, *Chaetophyllopsis whiteleggei, Goebelobryum unguiculatum* and occasionally the moss *Campylopus acuminatus* var. *kirkii* occur.

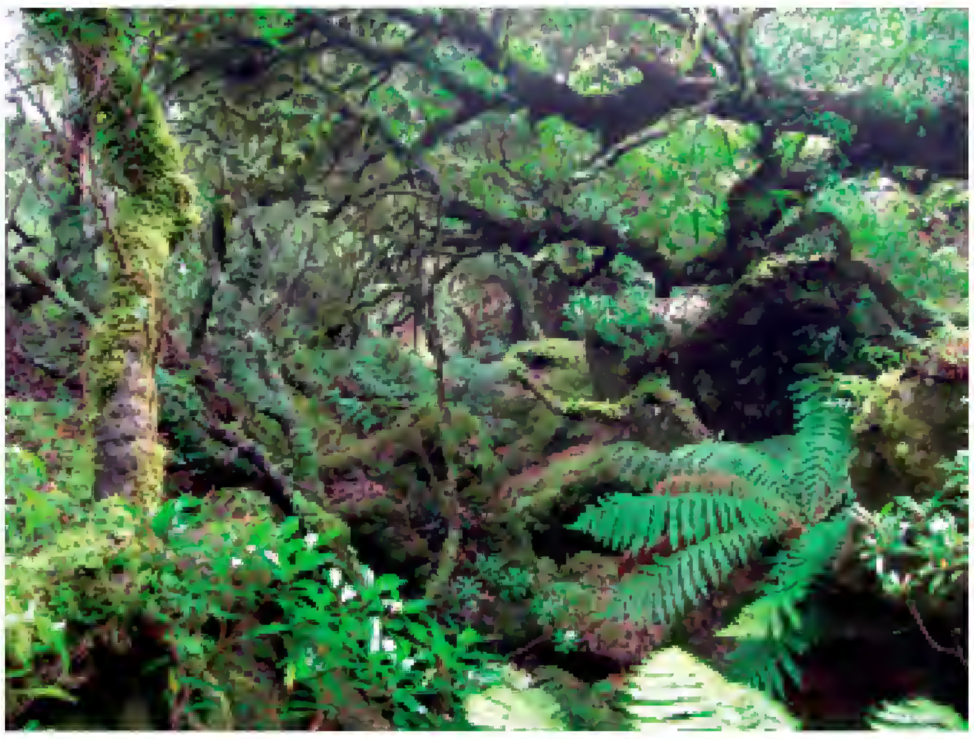

Fig. 6. The understorey of high altitude *Leptospermum lanigerum* forest with a dense bryophyte and fern ground layer.

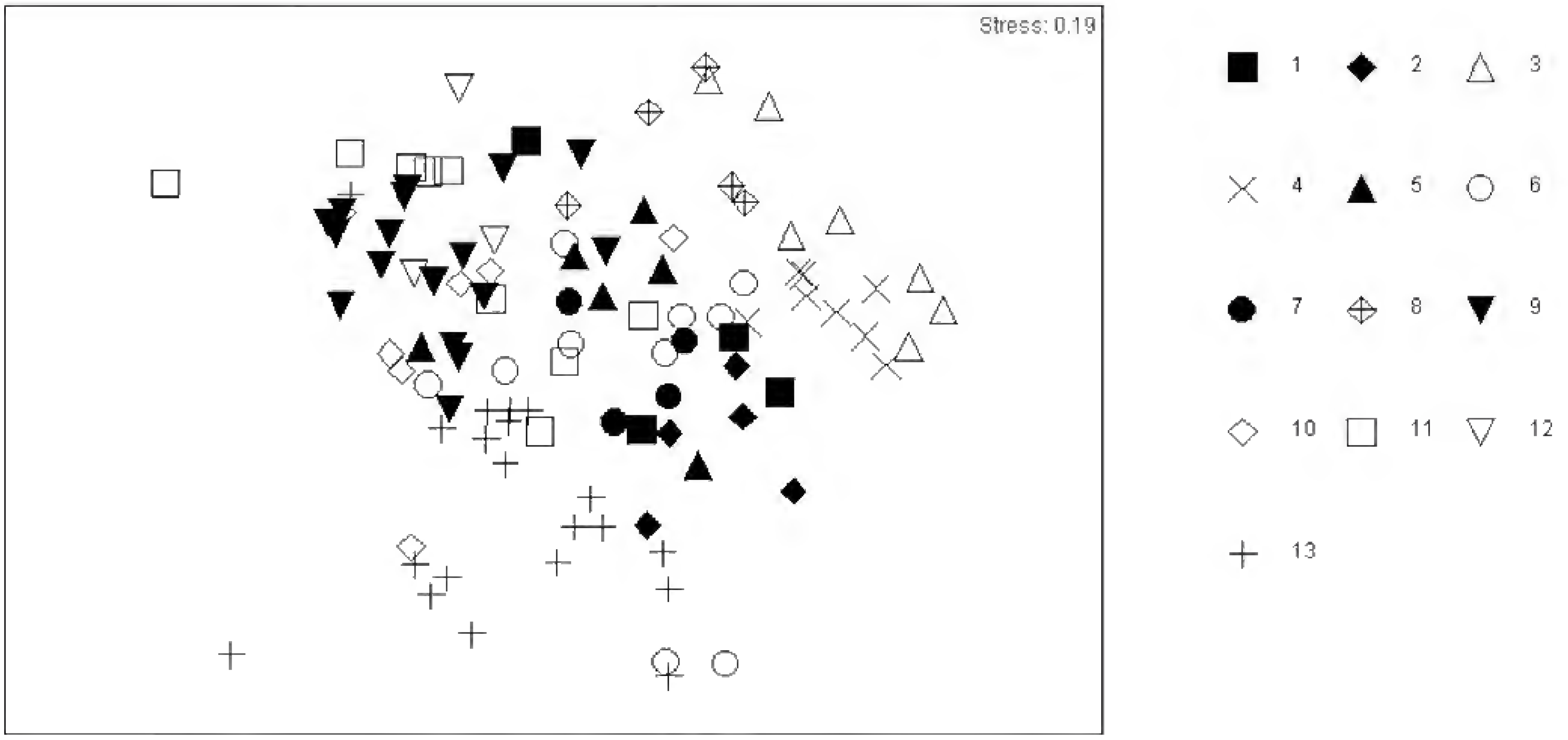

Fig. 7. Site bryophyte compositional similarity in northeast Tasmania, showing factors for vascular vegetation type (n=106): 1. *Eucalyptus amygdalina* coastal forest and woodland (dry), 2. *Melaleuca ericifolia* swamp forest, 3. Broad-leaf scrub / *Nothofagus-Atherosperma* rainforest, 4. *Eucalyptus viminalis* Furneaux forest and woodland (wet) / *Eucalyptus regnans* forest, 5. Dry Scrub, 6. *Eucalyptus nitida* Furneaux forest, 7. *Eucalyptus viminalis-Eucalyptus globulus* coastal forest and woodland, 8. *Eucalyptus amygdalina* coastal forest and woodland (wet), 9. *Leptospermum glaucescens* heathlands and scrubs / Coastal heathland (*Xanthorrhoea* dominant), 10. *Leptospermum glaucescens* heathlands and scrubs / Coastal Heathland (*Banksia* dominant), 11. Wet heathland (graminoid dominant), 12. Wet heathland (shrub dominant), 13. Coastal scrub on alkaline sands / Coastal grass and herbfield.

Away from the coast, the variation of climate and disturbance history at site level in Myrtaceous Scrub provides a range of habitat conditions for bryophytes, although the exposed position of this vegetation makes it incompatible for high bryophyte richness, except at higher elevation. In dry sites, desiccation tolerant species including the moss *Campylopus introflexus* and liverwort *Chiloscyphus semiteres* occur in patches on the ground. Bark of *Allocasuarina littoralis* and other shrub species occasionally have the moss *Sematophyllum homomallum, Rosulabryum billardieri* and liverworts *Frullania probisciphora* and *Frullania monocera*.

Dry scrub, woodland and forest vegetation has more complex topography, vegetation structure and contains a broad ecological subset of the island's bryoflora, partially due to more variation in habitat types at the site scale compared with aforementioned vegetation types. By far, most taxa are found near the ground and elevated substrates have few bryophyte taxa due to exposure. Examples can be seen in *Eucalyptus nitida* Forest where frequently occurring soil bryophytes include *Campylopus introflexus*, *Campylopus australis*, *Rhaphidorrhynchium amoenum*, *Rosulabryum billardieri*, *Hypnum cupressiforme*, *Ptychomnion aciculare*, *Ditrichum difficile* and *Dicranoloma billardieri*. On granite outcrops the mosses *Campylopus bicolor*, *Sclerodontium pallidum*, *Racopilum cuspiderum* var. *convolutaceum* and the liverworts *Acromastigum colensoanum*, *Ballantiopsis diplophylla, Metzgeria furcata* and *Cheilolejeunea mimosa* are relatively frequent. In wetter eucalypt dominated vegetation, bryophyte species occurring on bark include the mosses *Thuidiopsis sparsa*, *Wijkia extenuata*, *Sematophyllum homomallum* and the liverworts *Chiloschyphus semiteres*, *Telaranea tridactylis*, *Chiloscyphus villosus* and *Frullania falciloba*. The moss *Distichophyllum crispulum* is found in wetter examples of *Eucalyptus nitida* Forest and is known in Tasmania only from the Furneaux Islands; it is otherwise distributed along eastern temperate and tropical Australia to northern Queensland (AVH 2014). Within the Park, this species was recorded on soil, rock and *Dicksonia antarctica*. Rock outcrops provide distinctive bryophyte communities which are floristically similar to those described by Ashton and Webb (1977) for the northern extent of the Flinders bioregion on Wilsons Promontory. Bryophyte patches are often more extensively developed on the upper perimeter of granite sheets and in larger cracks where fed by moisture draining through the layers of vegetation above. Those species comprising the highest cover are typically the mosses *Campylopus bicolor, Sclerodontium pallidum, Dicranoloma menziesii* and the liverworts *Jamesoniella colorata* and *Balantiopsis diplophylla*. Rock outcrops in coastal areas have few bryophytes.

In *Melaleuca ericifolia* Forest, the aquatic liverwort *Chiloscyphus planiusculus* occurs submerged on the stream bank and rocks. The small liverworts *Kurzia compacta* and *Zoopsis leitgebiana* are a common component on the stream bank where they form contiguous mats over many square metres. Other species on soil include the mosses *Fissidens tenellus*, *Leucobryum candidum*, *Racopilum cuspidigerum* var. *convolutaceum*, *Rhyncostegium tenuifolium*, *Thuidiopsis sparsa* and *Wijkia extenuata* as well as the liverworts *Heteroscyphus coalitus* and *Chiloscyphus semiteres*. Soil disturbance by pigs provides suitable conditions for the liverwort *Lunularia cruciata*. *Eucalyptus viminalis* Forest has a more open canopy compared with *Melaleuca ericifolia* Forest and this combined with usually more substrate types contributes to a moderate diversity of bryophyte species. Granite boulders in *Eucalyptus viminalis* Forest include the liverworts *Acromastigum colensoanum*, *Heteroscyphus coalitus*, *Chiloscyphus latifolius*, *Metzgeria furcata*, *Symphyogyna podophylla*, *Balantiopsis diplophylla*, *Kurzia compacta* and the mosses *Hypnodendron vitiense*, *Dicranoloma menziesii*, *Camptochaete arbuscula* and *Rhynostegium tenuifoium*. Treefern trunks in this vegetation type include the epiphytic mosses *Rhizogonium distichum*, *Dicranoloma billardieri*, *Wijkia extenuata* and the liverworts *Chiloscyphus semiteres* and *Zoopsis leitgebiana* amongst others. The moss *Calyptrochaeta brownii* and the liverworts *Chiloscyphus villosus* and *Frullania monocera* are found often on the lower trunk of *Acacia melanoxylon*. *Sphagnum cristatum* occurs on the edge of water pools; this species is generally uncommon in eastern Bass Strait.

Rainforest-like conditions in Bass Strait such as those found in *Spyridium gunnii-Pomaderris apetala* Cloud Forest are very restricted spatially. Some taxa occur as a relic population in this community and, as such, are of biogeographic interest for south eastern Australia. Adjacent to this vegetation type, montane vegetation in the highest elevation zone of Mt Strzelecki represents the most bryophyte rich vegetation on Flinders Island with 55 taxa recorded during the current survey. Regionally important species include the moss *Calomnion complanatum* which occurs on treefern trunks, and a record at the headwater of Fotheringate Creek is an addition to the few documented sites (Meagher 1999) for this species in Tasmania, Victoria and New South Wales. Other bryophyte taxa apparently restricted to higher elevated areas in the Park include the liverworts *Marsupidium setulosum*, *Chandonanthus squarrosus*, *Anastrophyllum schismoides*, *Cuspidatula monodon*, *Jamesoniella colorata* and the moss *Rhacocarpus purpurascens*. In Tasmania, these taxa are otherwise found more commonly in rainforest or at higher elevation on the mainland (AVH 2014).

Fire

The interaction of fire with the Park vegetation has been profound. Different parts of the mountain range have different fire histories. The fire ages for which there is good evidence (including historical records, anecdotal reports and eucalypt ages) are 1948, about 1968, 1978 and 1994. There are charred eucalypt downers and stumps, the diameters of which suggest a fire-free interval until the time of their death of at least 100 years. The rainforest suggests a fire-free interval of several hundred years. Historical evidence indicates bushfires in the 1830s. Robinson in his journal entry for 11 January 1836 (Plomley 1987) remarked that they:

Saw immense smokes these several days past in different parts of the island and a long distance off. These are the smokes of the native fires

Again, on 3 February 1837: *Excessive hot fires these several days past and a great smoke*

In 1913 a party from the Royal Australian Ornithologist's Union (Mellor and White 1913) reported: *A party was formed to visit the lofty Strzelecki Ranges…..Approaching the ranges, which lay about 12 or 14 miles from the main camp, the party met with some fine forest country, thickly timbered with giant blue gums (Eucalyptus globulus). Bush fires had been raging, and many of the splendid trees were dead.*

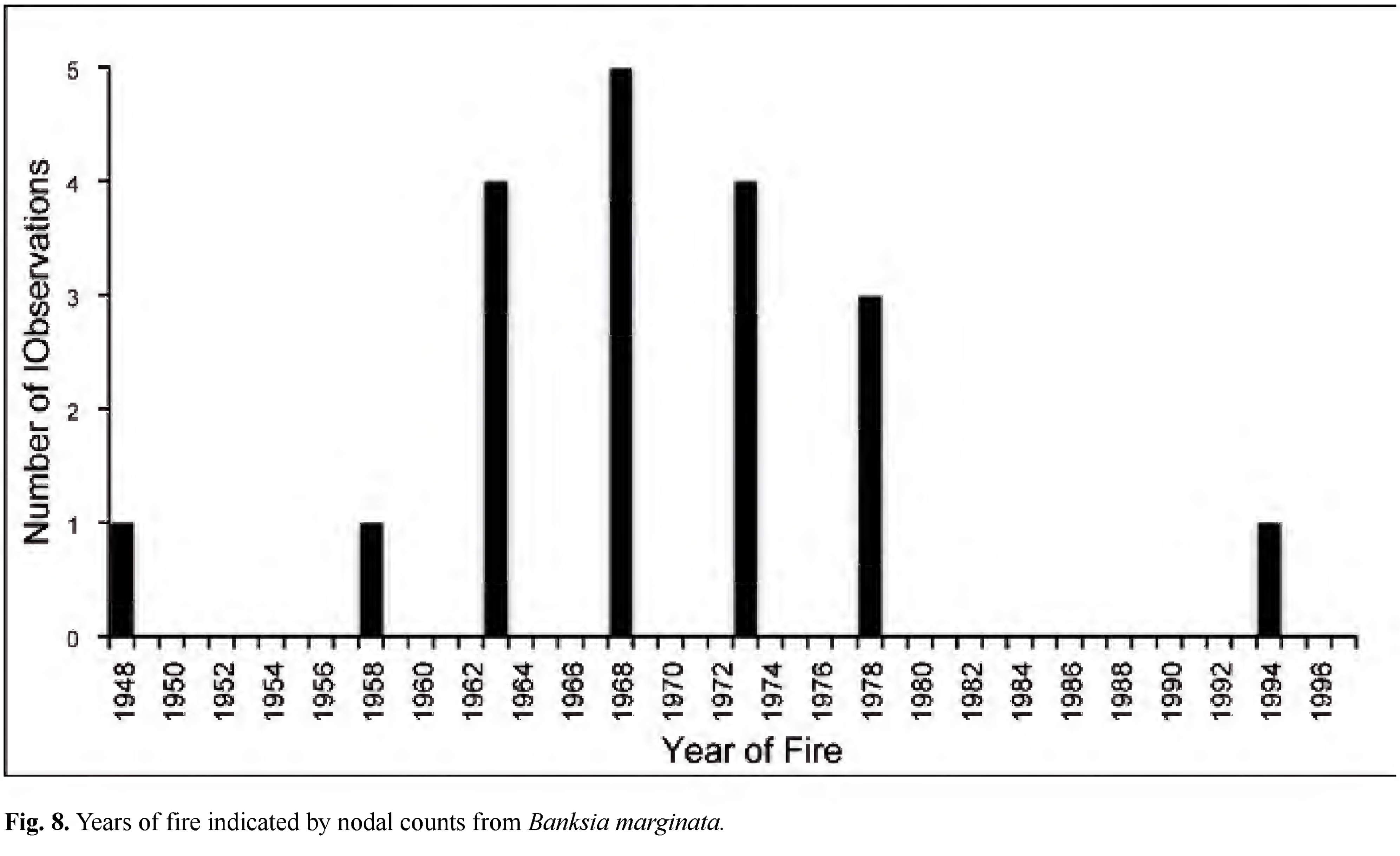

Fig. 8. Years of fire indicated by nodal counts from *Banksia marginata.*

The nodal counts on *Banksia marginata* (Figure 8) indicate germination events (fire) in 1963, 1968 and 1973. At least three *Banksia marginata* sites resulted in average counts indicating an origin for these years. Nodal counts yielding ages outside these years do not necessarily denote a major fire, as there was only 1 site each where trees were counted, and that indicated origins in the years 1948, 1958 and 1994. Spatially, the fire frequency is highest around the lower western slopes of the mountains, above and below the Big River Road where scrub and heath is concentrated. Fire frequency has also been higher on the flatter Crown land areas on the eastern side of the Park. Ignition sources are provided by the road on the western perimeter and farmland to the north and east and the Big River farm. More recent fires mask evidence of earlier ones especially where the vegetation is scrub and heath. In forests, evidence of past fires persists in the form of fire scars on trees or burnt downers and stumps.

The most fire-sensitive vegetation occurs in the headwaters of Fotheringate Creek where *Atherosperma moschatum* dominated rainforest persists because of the fire protection afforded by steep cliffs and boulder fields. This area is the most bryophyte species-rich on Flinders Island. Adjoining the forest is an extensive tract of *Leptospermum lanigerum* forest which has developed free of fire for many years. *Gahnia grandis* is present as a few straggly plants which have lost their vigour. The single age size class in the *Leptospermum lanigerum* suggests an intense fire regenerated this even-aged forest.

The rugged nature of the range provides a great deal of natural fire protection for much of the Park. Patches of tall *Eucalyptus viminalis* forest, rainforest, gallery forests with predominantly relict wet forest and rainforest elements and restricted *Callitris* communities, all benefit from low fire frequency due to position in the landscape. Filmy ferns and some bryophyte taxa are a good indicator of a long fire-free interval (Brown and Podger 1982). Filmy ferns were recorded in a large number of plots throughout the Park except around the perimeter of the mountains where there is less moisture and where fires would have had maximum impact on the ground layer. In much of the mountain range, incursion by fires may still have meant that complete incineration of the ground layer was impossible because of the rugged topography and boulders. Filmy ferns can escape destruction in protected crevices.

Examination of aerial photographs clearly shows the finer textured scrubs, heaths and young regenerating eucalypts as extensive skirting communities around the mountains which contrast with the coarser textured vegetation in the interior of the mountains. Even in the fastness of the mountains, many patches exhibiting different fire ages exist, resulting from spot fires and other disturbances. Escaped burns from around the edge of the mountains have enabled fire incursions with some attendant "spotting" into more remote areas.

The climax vegetation without fire would have been rainforest dominated by *Atherosperma moschatum, with Elaeocarpus reticulatus* co-dominant in the deeper valleys. Patches of climax dry rainforest occurred in boulder fields in valleys and some slopes. Large emergent *Eucalyptus globulus, Eucalyptus nitida* and *Eucalyptus viminalis* occurred with *Callitris rhomboidea* and *Allocasuarina verticillata* dominated forests on the more insolated slopes below the cloud forest layer. *Pomaderris apetala* and *Spyridium gunnii* dominated cloud forests on sites where the *Atherosperma moschatum* forest did not occur.

When humans began occupying the Furneaux Islands at the end of the eighteenth century, there had been a hiatus in human occupation of at least 4,000 years (Sim 1991). Although reconstruction of the vegetation is problematic, at the time of European arrival there was probably more extensive old rainforest and *Callitris* dominated forests on the mountains, and old eucalypt mixed forest and wet eucalypt forest. In any case the above-ground biomass would have been large because of the long fire interval. The earliest canopy fires in hot summer north easterly wind conditions would have been huge blazes, firestorms assisted by the winds and turbulence created around the mountains. Much of the Park would have been affected in this early period. Subsequent big fires have also spotted into the Park and because of the topography and wind turbulence that would exist in fire conditions, there would be some sites that have been burnt with great intensity and other sites incompletely burned.

Feral Pig Damage

Feral pigs occur throughout most of the study area and have certainly been present on Flinders Island since the nineteenth century. The Park is one of their main strongholds because there is plenty of cover for them and they are beyond disturbance by hunters. The rainfall is high enough to encourage the more rapid formation of damp humic soil horizon and water is abundant in the mountains.

We observed clear signs of pig rooting and/or pigs in 44 % of plot sites as well as pig disturbance along most of the traverses in between these plots. Pig damage was most obvious in the gullies where the organic soil was deeper, but was by no means confined to such areas. Damage was observed at all altitudes up to 700 m and in a range of vegetation types. Types of damage was noted frequently as: "pig ploughing in deep loamy soil", "lots of litter and ground disturbance from pigs – hoof marks evident", "litter pushed into heaps", "pig ploughing – deep dark humic loams. Sow with five piglets observed", "pig scats nearby", "deep litter except pigs have pushed up litter and mounds of bare soil". Impact on the vegetation is likely to have been profound but there is little chance to compare the present vegetation with what it was like before pigs were introduced, because we believe pigs now occupy all suitable habitat within the mountain range.

Some insight into the possible impacts can be judged from observations nonetheless. The prevalence of *Zieria arborescens*, a disturbance coloniser throughout the Park, even in areas free of fire (the usual initiator of *Zieria* regeneration) is likely due to ground disturbance caused by pigs. The bright green tone visible on aerial photographs across much of the mountain range is *Zieria arborescens* in the understorey. Some species may have been almost eliminated or at least severely depleted, particularly as pigs are probably exploiting 100% of certain habitats. For example, *Drymophila cyanocarpa* was recorded only once in our survey yet this small ground herb would have been expected in greater abundance. Fungi would be eaten and their fruiting bodies almost never observed in areas corresponding with recent pig disturbance. Similarly orchid tubers would be eaten. *Xerochrysum papillosum* is another disturbance requirer for pulse recruitment and is more abundant in the Park than would otherwise be expected. On the *Melaleuca* flats on the lower reaches of the Big River just outside the National Park boundary, *Blechnum nudum* would be the dominant ground cover except that it has been completely eliminated by the pigs and only a couple of remnant specimens remain where they occur under the lip of a stream bank. *Hypolepis rugosula*, a rhizomatous fern favoured by ground disturbance is abundant at the same site. At similar sites, *Histiopteris incisa*, which is also favoured by disturbance is abundant. Many areas were expected to have a 100% cover of bryophytes and ferns but had much less cover, or none, a condition attributable to the pigs. One site near plot 117, which was in the midst of an area extremely disturbed by pigs, had for some reason been untouched. This patch was bryophyte covered with many individuals of *Hydrocotyle hirta*, *Luzula flaccida*, *Microlaena stipoides*, *Wahlenbergia* sp. and *Zieria* seedlings.

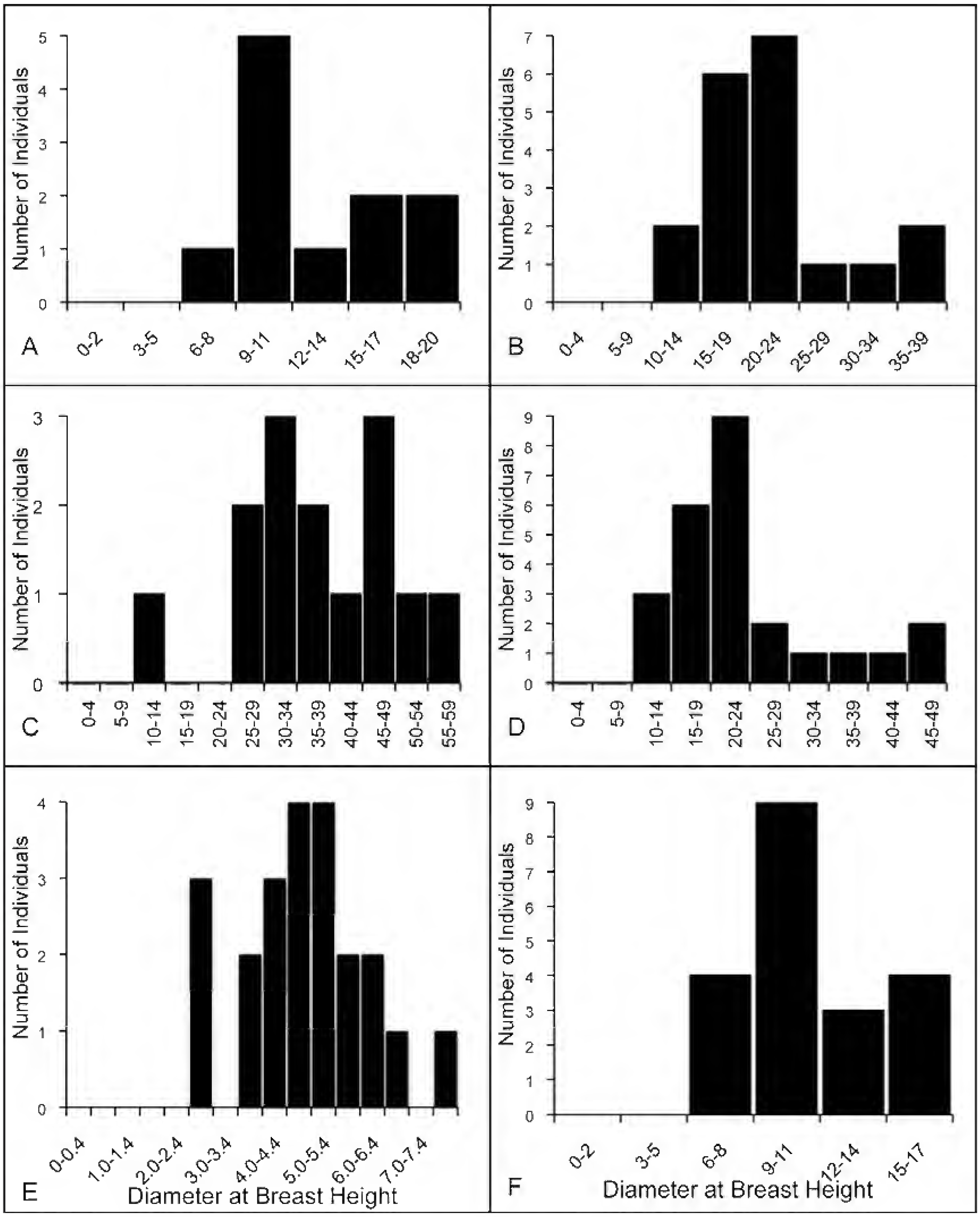

Fig. 9. Diameter at breast height in centimetres of *(A) Elaeocarpus reticulatus, (B) Eucalyptus nitida, (C) Acacia melanoxylon, (D) Melaleuca ericifolia, (E) Zieria arborescens, (F) Leptospermum scoparium.*

No evidence of pigs or pig damage was observed around the southern and eastern lower perimeter slopes of the mountain range, certainly very rarely below the 200 m contour. Soils for the most part here are siliceous shallow mineral soils with barely any organic horizon; this zone corresponds with the shorter fire-interval scrub and woodland vegetation.

The species stem diameter classes shown in figure 9 indicate different age cohorts. The largest stem ranges are 10-60 cm for *Acacia mela*noxylon, 10-50 cm for *Melaleuca ericifolia* and 10-40 for *Eucalyptus nitida*, all relatively long-lived trees. Stems for *Eleocarpus reticulatus* and *Leptospermum scoparium* range from 6-20 cm reflecting the shrubby habit of these species on the perimeter of the Park responding to more recent fires, while *Zieria arborescens* ranges from 2-8 cm, indicating more recent disturbance, either fire or feral pig ground disturbance.

Wind-throw

Wind-throw damage in the Strzelecki Range is sometimes spectacular and evidence for its effects is common. Wind gusts on Flinders have reached 131 km/hr at the coast, and is sufficiently strong to power large wind generators behind Whitemark. As expected, the winds would often be more severe at higher altitudes and given the rugged nature of the Strzelecki Range some considerable turbulence would result. On the coast the effect of onshore wind is demonstrated by the espalier effect on shrubs. In the mountains, the results of strong winds are more likely unpredictable and appear to have catastrophic effects on the vegetation.

In a few sites (for example at plot 49 on the shoulder of the Razorback), it appeared that a strong wind eddy had just blown a hole in the vegetation and lots of limbs and downers lay about on the ground. At the head of a watercourse about 1.5 km due south of the Razorback, *Allocasuarina verticillata* trees up to 15 m high have been blown over and the resulting gap in the forest canopy is up to 250 m across. At 680 m altitude areas of broken canopy occur in the dense closed *Leptospermum lanigerum* low closed forest. We venture the cause of these as being strong wind eddies. Once a gap or hole is created, the way is open for more damage to occur at a later time. For example, just off the main road 2 km north of the Trousers Point turnoff, wind has penetrated a stand of *Eucalyptus globulus-Eucalyptus nitida-Allocasuarina verticillata* and created a blowdown area of about 10 m by 5 m. The roadside edges normally allow some wind protection because of the dense shrubbery but if this is breached then vegetation can be affected. Sites where scrub or forest has developed on skeletal soil on granite slabs or steep sites are particularly vulnerable. Even last century, observations were made about wind throw on a climb up Mt Strzelecki (Gabriel 1894): *At the foot of this peak was a nasty belt of ti-tree, which had been under the influence of fire or something else, and had been blown down with the branches the wrong way.*

Discussion

Strzelecki National Park is a dramatic landscape with the highest mountains in Bass Strait. The altitude contributes to the cloud capping and consequent elevated moisture availability in the mountains. The ruggedness is due to the deeply dissected granite topography and it is likely that the ranges have remained above sea level during glacial and inter-glacial cycles. Together these factors have created niches for vegetation that have been protected from fire for long periods. The consequence is the occurrence of fire sensitive plant communities and plant species that occur nowhere else in Bass Strait and may be sufficiently removed from their nearest congeners to have allowed some evolutionary isolation. Unlike most of Australia there was no Aboriginal presence on the island, therefore no human-initiated fire, for several thousand years but no part of the Park has been completely isolated from fire; there is evidence of lightning strikes being common on the Strzelecki Ranges (as well as the Darling Ranges further north on Flinders Island). Localised fires may start from these; in the Strzelecki Ranges the effect may be highly localised whereas in the drier Darling Ranges lightning initiated fire has been observed to burn large areas of country. Fire frequency would have accelerated with European settlement in eastern Bass Strait in the early nineteenth century; the fires used to clear bush in the early part of the twentieth century burned well up the flanks of the mountains. Spot fires no doubt initiated some of the even-aged eucalypt cohorts in the Park.

Fire is the greatest single consideration in future vegetation management and a fire plan for the National Park and surrounding Crown land should consider fire sensitive vegetation types which will benefit from fire exclusion. Some vascular and non-vascular plant taxa may become extinct on Flinders Island if long-unburnt higher elevation communities are subjected to a different fire regime. The low nutrient granite soils mean a slow return time to pre-fire vegetation condition for burnt rainforest or wet forests.

Currently anticipated changes in regional climate parameters are unlikely to increase the likelihood of adverse conditions for the vegetation, because of the persistence of the fundamental biophysical factors - the constant westerly airstreams and mountain height. Continuation of the high moisture regime in the mountains will continue to aid the persistence of the fire protected communities in the core of the Park.

The presence of highly flammable vegetation around the Park perimeter and occasional high wind speeds and increased air turbulence caused by the steep topography, indicate the likelihood of intense fire storms under certain conditions. Ignition sources may be lightning strikes or more probably from escaped fuel reduction fires along the Park perimeter. Some intense fires have no doubt entered the mountain ranges but the fire frequency around the Park perimeter is clearly much higher.

Fires will originate from outside the Park and burn into it. Management actions should include: encouraging adjoining landholders to cooperate and co-own the prescriptions, having some strategically placed and well maintained fire breaks, closing certain access points in periods of extreme fire danger. Some small patch burning around the perimeters of the Park will be necessary. Fuel reduction burns of the Park on any more than a localised or peripheral scale are not considered necessary or desirable however fire suppression should be considered under some circumstances.

Future Studies

Strzelecki National Park is a unique site for further natural history. We recommend a complete exploration of the lichen flora and its documentation and further sampling of bryophytes within the higher elevations areas is needed to gain a better understanding of the distribution of apparently very rare species to guide management of the Park's biodiversity.

The vegetation communities subject to episodic cloud cover deserve more study, both from a comparative viewpoint with other cloud forests, and in terms of ecophysiological processes within them. Very little literature exists on cloud forests outside of the tropical regions. To assist with future studies, automated climatic station devices capable of recording and transmitting basic climate data need to be placed in the higher part of the mountains.

Feral pigs have had a noticeable impact on the environment in the Park by destroying groundlayer vegetation and stimulating disturbance requirers such as *Zieria arborescens*. We have noted a range of other impacts on flora and there will inevitably be impacts on soil invertebrate fauna. Feral pig eradication may need to be addressed in the context of an eradication plan across the whole of Flinders Island because migration occurs back and forth into the Park from other parts of the island. Notwithstanding this the Park and adjoining bush is bounded by farmland to the north and east, and is a discrete unit within which to control and then eradicate pigs through the use of baited trapping stations and shooting.

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Chris Arthur, formerly of the Parks and Wildlife Service provided a sketch map of old fire boundaries as well as providing encouragement and showing us the feral pig traps on the fire trail. The authors are pleased to thank Louisa d'Arville and Spencer Chung (both formerly of DPIPWE) who assisted with preparation of the figures. Assistance in the field was provided by Eve Lazarus, Meredith Reardon, Sue Backhouse, Adrian Heard, Andrew Rozefelds, Danielle Wood, Linda Bester and David Cameron. Arduous traverses, often involving overnight bivouacs were cheerfully undertaken at various times by these excellent companions. Candida Barclay (Invasive Species Branch, DPIPWE) discussed the potential use of the feral pig data collected and how it can inform management. Hans Wapstra identified some orchid species.

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APPENDIX 1. List of Non-vascular plants (liverworts and mosses) and Vascular plants (ferns, conifers and flowering plants) in family order, recorded from Strzelecki National Park, Flinders Island, Tasmania.

Vascular flora compiled 2013; bryophytes 2013

r – listed as rare or threatened in Tasmania (Tasmanian *Threatened Species Protection Act 1995*),
e – endemic to Tasmania,
i – taxa introduced to the Park since European settlement.

Liverworts (MARCHANTIOPHYTA)

ACROBOLBACEAE
- *Acrobolbus concinnus*
- *Goebelobryum unguiculatum*
- *Lethocolea pansa*
- *Marsupidium setulosum*
- *Marsupidium surculosum*
- *Tylimanthus diversifolius*
- *Tylimanthus tenellus*

ADELANTHACEAE
- *Adelanthus bisetulus*
- *Calyptrocolea falcata*

ANERUACEAE
- *Riccardia crassa*

BALANTIOPSIDACEAE
- *Balantiopsis diplophylla*
- *Balantiopsis tumida*

CEPHALOZIELLACEAE
- *Cephaloziella exiliflora*
- *Cephaloziella hirta*

GEOCALYCACEAE
- *Chiloscyphus latifolius*
- *Chiloscyphus semiteres*
- *Chiloscyphus villosus*
- *Heteroscyphus biciliatus*
- *Heteroscyphus coalitus*
- *Heteroscyphus fissistipus*
- *Heteroscyphus knightii*
- *Heteroscyphus planiusculus*
- *Heteroscyphus supinus*

HYMENOPHYTACEAE
- *Hymenophyton flabellatum*

JUBULACEAE
- *Frullania clavata*
- *Frullania deplanata*
- *Frullania falciloba*
- *Frullania monocera*
- *Frullania probosciphora*
- *Frullania rostrata*

JUNGERMANNIACEAE
- *Anastrophyllum schismoides*
- *Chandonanthus squarrosus*
- *Cuspidatula monodon*
- *Jamesoniella colorata*

- LEJEUNACEAE
  - *Cheilolejeunea mimosa*
- LEPICOLEACEAE
  - *Lepicolea scolopendra*
- LEPIDOLAENACEAE
  - *Gackstroemia weindorferi*
- LEPIDOZIACEAE
  - *Acromastigum colensoanum*
  - *Bazzania adnexa*
  - *Bazzania monilinervis*
  - *Kurzia compacta*
  - *Lepidozia glaucophylla*
  - *Lepidozia laevifolia var. laevifolia*
  - *Lepidozia ulothrix*
  - *Telaranea tridactylis*
  - *Telaranea centipes*
  - *Telaranea herzogii*
  - *Zoopsis argentea*
  - *Zoopsis leitgebiana*
- LUNULARIACEAE
  - *Lunularia cruciata*
- MARCHANTIACEAE
  - *Marchantia berteroana*
- METZGERIACEAE
  - *Metzgeria furcata*
- PALLAVICINIACEAE
  - *Symphyogyna podophylla*
- PLAGIOCHILACEAE
  - *Plagiochila fasciculata*
  - *Plagiochila strombifolia*
- RADULACEAE
  - *Radula buccinifera*
  - *Radula compacta*
- TRICHOCOLEACEAE
  - *Trichocolea mollissima*

Mosses (BRYOPHYTA)

- ANDREAEACEAE
  - *Andreaea amblyophylla*
- BARTRAMIACEAE
  - *Breutelia affinis*
- BRACHYTHECIACEAE
  - *Brachythecium rutabulum*
  - *Rhynchostegium tenuifolium*
- BRYACEAE
  - *Gemmabryum cheelii*
  - *Rosulabryum billarderi*
  - *Rosulabryum capillare*
- CALOMNIACEAE
  - *Calomnion complanatum*
- DICRANACEAE
  - *Dicranoloma billarderi*
  - *Dicranoloma menziesii* var. *menziesii*
  - *Sclerodontium pallidum* subsp. *pallidum*
- DITRICHACEAE
  - *Ceratodon purpureus* subsp. *convolutus*
  - *Ditrichum difficile*
- FISSIDENTACEAE
  - *Fissidens curvatus* var. *curvatus*
  - *Fissidens* sp.
  - *Fissidens tenellus* var. *tenellus*
  - *Fissidens taylorii*
- FUNARIACEAE
  - *Entosthodon subnudus* var. *gracilis*
  - *Funaria hygrometrica*
- GIGASPERMACEAE
  - *Gigaspermum repens*
- GRIMMIACEAE
  - *Grimmia laevigata*
  - *Grimmia pulvinata* var. *africana*
  - *Racomitrium crispulum*
- HEDWIGIACEAE
  - *Hedwigia ciliata*
  - *Hedwigidium integrifolium*
- HOOKERIACEAE
  - *Achrophyllum dentatum*
  - *Calyptrochaeta apiculata*
  - *Calyptrochaeta brownii*
  - *Distichophyllum crispulum*
  - *Distichophyllum pulchellum*
- HYPNACEAE
  - *Hypnum chrysogaster*
  - *Hypnum cupressiforme*
  - *Hypnum cupressiforme* var. *lacunosum*
  - *Hypnum cupressiforme* var. *mossmanianum*
- HYPNODENDRACEAE
  - *Hypnodendron vitiense* subsp. *australe*
- HYPOPTERYGIACEAE
  - *Cyathophorum bulbosum*
- LEMBOPHYLLACEAE
  - *Camptochaete arbuscula* var. *arbuscula*
  - *Camptochaete deflexa*
  - *Lembophyllum divulsum*
  - *Weymouthia mollis*
- LEPTOSTOMATACEAE
  - *Leptostomum inclinans*
- LEUCOBRYACEAE
  - *Campylopus australis*
  - *Campylopus acuminatus* var. *kirkii*
  - *Campylopus bicolor* var. *bicolor*
  - *Campylopus introflexus*
  - *Campylopus pyriformis*
  - *Leucobryum candidum*
- METEORIACEAE
  - *Papillaria flavolimbata*
- MITTENIACEAE
  - *Mittenia plumula*
- ORTHODONTIACEAE
  - *Orthodontium lineare*
- ORTHOTRICHACEAE
  - *Macrocoma tenuis* subsp. *tenuis*
  - *Macromitrium microstomum*
  - *Zygodon menziesii* var. *menziesii*
  - *Zygodon minutus*
- PLAGIOTHECIACEAE
  - *Catagonium nitens* subsp. *nitens*

POLYTRICHACEAE
- *Polytrichum juniperinum*

POTTIACEAE
- *Barbula calycina*
- *Calyptopogon mnioides*
- *Tortula antarctica*
- *Trichostomum eckelianum*
- *Triquetrella papillata*
- *Weissia controversa*

PTYCHOMNIACEAE
- *Ptychomnion aciculare*

RHACOCARPACEAE
- *Rhacocarpus purpurascens*

RACOPILACEAE
- *Racopilum cuspidigerum* var. *convolutaceum*

RHIZOGONIACEAE
- *Hymenodon pilifer*
- *Leptotheca gaudichaudii* var. *gaudichaudii*
- *Rhizogonium distichum*
- *Rhizogonium novae-hollandiae*

SEMATOPHYLLACEAE
- *Rhaphidorrhynchium amoenum*
- *Sematophyllum homomallum*
- *Wijkia extenuata*

SPHAGNACEAE
- *Sphagnum cristatum*
- *Sphagnum falcatulum*
- *Sphagnum novozelandicum*

SPHLACHNACEAE
- *Tayloria octoblepharum*

TRACHYLOMATACEAE
- *Trachyloma planifolium*

THUIDIACEAE
- *Thuidiopsis furfurosa*
- *Thuidiopsis sparsa*

Ferns
(PTERIDOPHYTA)

ADIANTACEAE
- *Pellaea falcata*

ASPLENIACEAE
- *Asplenium appendiculatum*
- *Asplenium bulbiferum* subsp. *gracillimum*
- *Asplenium flabellifolium*
- *Asplenium obtusatum* subsp. *northlandicum*

BLECHNACEAE
- *Blechnum nudum*
- *Blechnum pennamarina* subsp. *alpina*
- *Blechnum wattsii*

CYATHEACEAE
- *Cyathea australis*

DENNSTAEDTIACEAE
- *Histiopteris incisa*
- r *Hypolepis muelleri*
- *Hypolepis rugosula*
- *Pteridium esculentum*

DICKSONIACEAE
- *Dicksonia antarctica*

DRYOPTERIDACEAE
- *Lastreopsis acuminata*
- *Polystichum proliferum*
- *Rumohra adiantiformis*

GLEICHENIACEAE
- *Gleichenia dicarpa*
- *Gleichenia microphylla*
- *Sticherus tener*

GRAMMITIDACEAE
- *Ctenopteris heterophylla*
- *Grammitis billardierei*
- *Grammitis magellanica* subsp. *nothofageti*

HYMENOPHYLLACEA
- *Hymenophyllum australe*
- *Hymenophyllum cupressiforme*
- *Hymenophyllum flabellatum*
- *Hymenophyllum marginatum*
- *Hymenophyllum rarum*
- *Crepidomanes venosum*

LINDSAEACEAE
- *Lindsaea linearis*

LYCOPODIACEAE
- *Huperzia varia*
- *Lycopodium deuterodensum*

OSMUNDACEAE
- *Todea barbara*

POLYPODIACEAE
- *Microsorum pustulatum* subsp. *pustulatum*

PSILOTACEAE
- *Tmesipteris obliqua*
- r *Tmesipteris parva*

PTERIDACEAE
- *Pteris tremula*

SCHIZAEACEAE
- *Schizaea bifida*
- *Schizaea fistulosa*

SELAGINELLACEAE
- *Selaginella uliginosa*

Conifers
(GYMNOSPERMAE)

CUPRESSACEAE
- *Callitris rhomboidea*

Flowering plants – monocots
(MONOCOTYLEDONAE)

CENTROLEPIDACEAE
- *Centrolepis strigosa*

CYPERACEAE
- *Baumea acuta*
- *Carex appressa*
- *Ficinia nodosa*
- *Gahnia grandis*
- *Gymnoschoenus sphaerocephalus*
- *Isolepis aucklandica*
- *Isolepis cernua*

- *Isolepis marginata*
- *Lepidosperma concavum*
- *Lepidosperma elatius*
- *Lepidosperma ensiforme*
- *Lepidosperma filiforme*
- *Lepidosperma gunnii*
- *Lepidosperma longitudinale*
- *Schoenus carsei*
- *Schoenus lepidosperma* subsp. *lepidosperma*
- *Tetraria capillaris*
- *Uncinia tenella*

- IRIDACEAE
  - *Patersonia fragilis*
- JUNCACEAE
  - *Juncus pauciflorus*
  - *Juncus planifolius*
  - i *Luzula campestris*
  - *Luzula flaccida*
- LILIACEAE
  - *Dianella brevicaulis*
  - *Dianella revoluta*
  - *Dianella tasmanica*
  - *Drymophila cyanocarpa*
  - *Thelionema caespitosum*
- ORCHIDACEAE
  - *Acianthus caudatus*
  - *Acianthus pusillus*
  - *Burnettia cuneata*
  - *Caladenia carnea*
  - *Caladenia dilatata*
  - *Caladenia mentiens*
  - *Caladenia vulgaris*
  - e *Calochilus herbaceus*
  - e, r *Corunastylis brachystachya*
  - *Corybas unguiculatus*
  - *Diuris orientis*
  - *Dockrillia striolata* subsp. *striolata*
  - *Gastrodia sesamoides*
  - *Prasophyllum brevilabre*
  - *Prasophyllum flavum*
  - *Prasophyllum* sp. aff. *pyriformis*
  - *Pterostylis alata*
  - *Pterostylis melagramma*
  - *Pterostyls nana*
  - *Pterostylis nutans*
  - *Ptrostylis parviflora*
  - *Pterostylis pedunculata*
  - *Pterostylis pedoglossa*
  - *Pterostylis tasmanica*
  - *Pterostylis tunstallii*
  - *Thelymitra flexuosa*
  - *Thelymitra holmesii*
  - *Thelymitra rubra*
- POACEAE
  - *Agrostis venusta*
  - *Austrostipa stipoides*
  - i *Catapodium* sp.
  - *Deyeuxia monticola*
  - *Deyeuxia quadriseta*
  - *Distichlis distichophylla*
  - *Echinopogon ovatus*
  - *Hierochloe redolens*
  - i *Holcus lanatus*
  - i *Lagurus ovatus*
  - *Microlaena stipoides* var. *stipoides*
  - *Poa poiformis* var. *poiformis*
  - *Rytidosperma penicillatum*
  - *Rytidosperma* sp.
  - *Spinifex sericeus*
  - *Tetrarrhena distichophylla*
  - *Zoysia macrantha* subsp. *walshii*
- RESTIONACEAE
  - *Baloskion australe*
  - *Eurychorda companata*
  - *Empodisma minus*
  - *Leptocarpus tenax*
- XANTHORRHOEACEA
  - *Xanthorrhoea australis*
- XYRIDACEAE
  - *Xyris operculata*

Flowering plants – dicots (DICOTYLEDONAE)

- AIZOACEAE
  - *Carpobrotus rossii*
  - *Disphyma crassifolium* subsp. *clavellatum*
  - *Tetragonia implexicoma*
- APIACEAE
  - *Apium prostratum*
  - *Centella cordifolia*
  - *Daucus glochidiatus*
  - *Eryngium vesiculosum*
  - *Hydrocotyle capillaris*
  - *Hydrocotyle hirta*
  - *Hydrocotyle muscosa*
  - *Hydrocotyle sibthorpioides*
  - *Trachymene composita* var. *composita*
  - *Xanthosia pilosa*
- APOCYNACEAE
  - *Alyxia buxifolia*
  - *Parsonsia brownii*
- ASTERACEAE
  - *Angianthus preissianus*
  - *Apalochlamys spectabilis*
  - i *Carduus tenuiflorus*
  - *Cassinia aculeata*
  - i *Cirsium vulgare*
  - *Cotula* sp.
  - *Euchiton japonicus*
  - *Gnaphalium indutum*
  - *Helichrysum paralium*
  - *Helichrysum* sp.
  - i *Hypochaeris radicata*
  - *Lagenophora* sp.
  - i *Leontodon saxatilis*
  - *Leptinella longipes*
  - *Leucophyta brownii*

Olearia argophylla
Olearia lirata
Olearia phlogopappa subsp. *phlogopappa*
Olearia ramulosa
Olearia stellulata
Ozothamnus argophyllus
Ozothamnus turbinatus
Senecio pinnatifolius
i *Sonchus asper*
i *Sonchus oleraceus*
Xerochrysum bracteatum
Xerochrysum papillosum
BRASSICACEAE
i *Cakile maritima* subsp. *maritima*
CALLITRICHACEAE
i *Callitriche stagnalis*
CAMPANULACEAE
Lobelia anceps
Wahlenbergia gracilenta
Wahlenbergia sp.
CARYOPHYLLACEAE
i *Cerastium glomeratum*
Colobanthus apetalus var. *apetalus*
Sagina sp.
CASUARINACEAE
Allocasuarina littoralis
e *Allocasuarina monilifera*
Allocasuarina verticillata
CHENOPODIACEAE
Atriplex billardierei
Atriplex cinerea
Rhagodia candolleana subsp. *candolleana*
Sarcocornia quinqueflora
Threlkeldia diffusa
CLUSIACEAE
Hypericum sp.
CONVOLVULACEAE
Dichondra repens
CRASSULACEAE
Crassula sieberiana
DILLENIACEAE
Hibbertia hirticalyx
Hibbertia prostrata
DROSERACEAE
Drosera auriculata
Drosera pygmaea
ELAEOCARPACEAE
r *Elaeocarpus reticulatus*
EPACRIDACEAE
Astroloma humifusum
Epacris impressa
Epacris lanuginosa
Epacris paludosa
Leptecophylla juniperina subsp. *juniperina*
Leptecophylla juniperina subsp. *oxycedrus*
Leptecophylla pendulosa
Lissanthe strigosa subsp. *subulata*
Leucopogon ericoides
Leucopogon parviflorus
Monotoca elliptica
Monotoca glauca
Sprengelia incarnata
EUPHORBIACEAE
Amperea xiphoclada var. *xiphoclada*
Beyeria lechenaultii
Beyeria viscosa
Phyllanthus gunnii
Poranthera microphylla
FABACEAE
Aotus ericoides
Daviesia ulicifolia subsp. *rusifolia*
Dillwynnia sericea
r *Eutaxia microphylla*
Goodia lotifolia
Platylobium triangulare
Pultenaea daphnoides
Swainsona lessertiifolia
i *Trifolium repens*
GERANIACEAE
Pelargonium australe
GOODENIACEAE
Goodenia ovata
Selliera radicans
HALORAGACEAE
Gonocarpus sp.
Gonocarpus teucrioides
HYPOPTERYGIACEAE
Cyathophorum bulbosum
LAMIACEAE
Ajuga australis
e *Westringia brevifolia*
LAURACEAE
Cassytha glabella
Cassytha melantha
Cassytha pubescens
LENTIBULARIACEAE
Utricularia tenella
MALVACEAE
Gynatrix pulchella
MIMOSACEAE
Acacia genistifolia
Acacia melanoxylon
e *Acacia mucronata* subsp. *mucronata*
MONIMIACEAE
Atherosperma moschatum subsp. *moschatum*
MYOPORACEAE
Myoporum insulare
r *Myoporum parviflorum*
MYRTACEAE
Calytrix tetragona
Eucalyptus globulus subsp. *globulus*
e *Eucalyptus nitida*
Eucalyptus viminalis subsp. *viminalis*
Kunzea ambigua
e *Leptospermum glaucescens*
e *Leptospermum grandiflorum*
Leptospermum laevigatum
Leptospermum lanigerum

Leptospermum scoparium
Melaleuca ericifolia
Melaleuca gibbosa
Melaleuca pallida
Melaleuca squamea
Melaleuca squarrosa
OLEACEAE
Notelaea ligustrina
OXALIDACEAE
Oxalis perennans
Oxalis rubens
PITTOSPORACEAE
Billardiera mutabilis
Bursaria spinosa
Pittosporum bicolor
PLANTAGINACEAE
e *Plantago bellidioides*
i *Plantago coronopus*
e *Plantago tasmanica*
POLYGALACEAE
Comesperma volubile
POLYGONACEAE
Muehlenbeckia adpressa
PORTULACACEAE
Calandrinia calyptrata
Montia sp.
PRIMULACEAE
i *Lysimachia arvensis*
PROTEACEAE
Banksia marginata
Hakea decurrens subsp. *platytaenia*
e *Hakea epiglottis*
Hakea lissosperma
e *Hakea megadenia*
Hakea teretifolia subsp. *hirsuta*
Isopogon ceratophyllus
e *Lomatia tinctoria*
Persoonia juniperina
RANUNCULACEAE
Clematis aristata
Clematis microphylla
Ranunculus sp.
RHAMNACEAE
Pomaderris apetala subsp. *apetala*
e *Pomaderris elliptica* var. *diemenica*
Pomaderris elliptica var. *elliptica*
r *Pomaderris oraria*
Pomaderris pilifera
e *Spyridium gunnii*
e *Spyridium obovatum* var. *obovatum*
ROSACEAE
Acaena novae-zelandiae
i *Sanguisorba minor*
RUBIACEAE
Asperula conferta
r *Asperula minima*
Asperula oblanceolata
Coprosma hirtella
Coprosma quadrifida
Galium australe
Opercularia varia
RUTACEAE
Boronia anemonifolia subsp. *variabilis*
Correa backhouseana var. *backhouseana*
Correa reflexa
Leionema bilobum
Zieria arborescens subsp. *arborescens*
SANTALACEAE
Exocarpos syrticola
SAPINDACEAE
Dodonaea viscosa subsp. *spatulata*
SCROPHULARIACEAE
Veronica calycina
SOLANACEAE
i *Lycium ferocissimum*
Solanum laciniatum
STACKHOUSIACEAE
Stackhousia monogyna
STERCULIACEAE
Lasiopetalum macrophyllum
STYLIDIACEAE
Stylidium graminifolium
THYMELAEACEAE
Pimelea curviflora
Pimelea drupacea
Pimelea linifolia subsp. *linifolia*
e *Pimelea nivea*
Pimelea serpyllifolia subsp. *serpyllifolia*
URTICACEAE
r *Parietaria debilis*
Urtica incisa
VIOLACEAE
Viola fuscoviolacea
Viola hederacea
WINTERACEAE
Tasmannia lanceolata

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Classifying and mapping the Australian Alps' Native Vegetation

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Abstract: Strategic and systematic planning for bioregional landscapes that cross jurisdictions is often hampered by different approaches to collecting, classifying and mapping information on the native vegetation cover in terms of major community types. The network of Australian Alps National Parks is one such multi-jurisdictional bioregional landscape consisting of 11 protected areas spanning 1.6 million hectares across Victoria, New South Wales and the Australian Capital Territory. Although the Alps network has a co-operative management program and the parks are listed as National Heritage, there is no common vegetation classification system or map at a scale suitable for management. As part of developing a strategic framework to assist biodiversity conservation for the whole of the Alps Network, a common vegetation classification and map was produced. The new classification utilised existing State vegetation classes and mapping to produce a common system by matching 71 NSW/ACT vegetation groups with 72 Victorian ecological vegetation classes, thereby resulting in 17 common vegetation classes with affinities with other studies described. The 17 vegetation classes also group into five broad vegetation character classes. Expert knowledge was used to match vegetation groups and classes. The resulting classification and map are available as a GIS data layer and as part of a decision support data-pack. This approach provides a low cost method for developing a common vegetation system across multi-jurisdictional landscapes, without replacing State-based systems, and in a format that can be readily updated in light of new field surveys and remotely sensed data. The new classification and map are available for download from an online data repository. This new vegetation information can be applied to help promote a whole-of-landscape approach to planning and management of the Alps Network.

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Introduction

Information on the composition, structure and distribution of major vegetation types is fundamental for the systematic conservation planning and management of protected areas. Providing data sets with a common coverage, however, can be problematic for protected area networks that span large, multi-jurisdictional landscapes. While encompassing the same bioregions and ecosystem types, different vegetation classification and mapping systems often arise independently over time.

The Australian Alps National Parks Network (hereafter, the Alps Network) comprises 11 protected areas spanning 1.6 million ha across the states of Victoria, New South Wales (NSW) and the Australian Capital Territory (ACT) (Table 1, Figure 1). Currently, each State and territory government agency manages the park areas within its jurisdiction. Interagency cooperation is promoted through the Australian Alps Co-operative Management Program (Australian Alps Liaison 2012). There is, however, no whole-of-Alps management plan or common database of biodiversity information. Vegetation classifications and lists of threatened and endangered species are recorded separately using State and Commonwealth based systems with different standards and criteria.

NSW/ACT and Victoria have independently developed vegetation classification and mapping systems. The different methods have resulted in major mismatches which are most apparent at state and territorial borders. The National Vegetation Information System (Department of the Environment and Heritage 2003) has generated continental coverage of native vegetation which spans the Alps Network but the classification and scale of mapping are coarse, omitting a number of vegetation types that are characteristic of the bioregion and providing insufficient detail for park planning and management purposes. There remains the need for an appropriately scaled common vegetation classification and map for the Alps Network that can complement remotely sensed data on land cover change including weed impacts (Deehan *et al*. 2007) and updated information about the flora of this complex bioregion (Doherty *et al*. 2015).

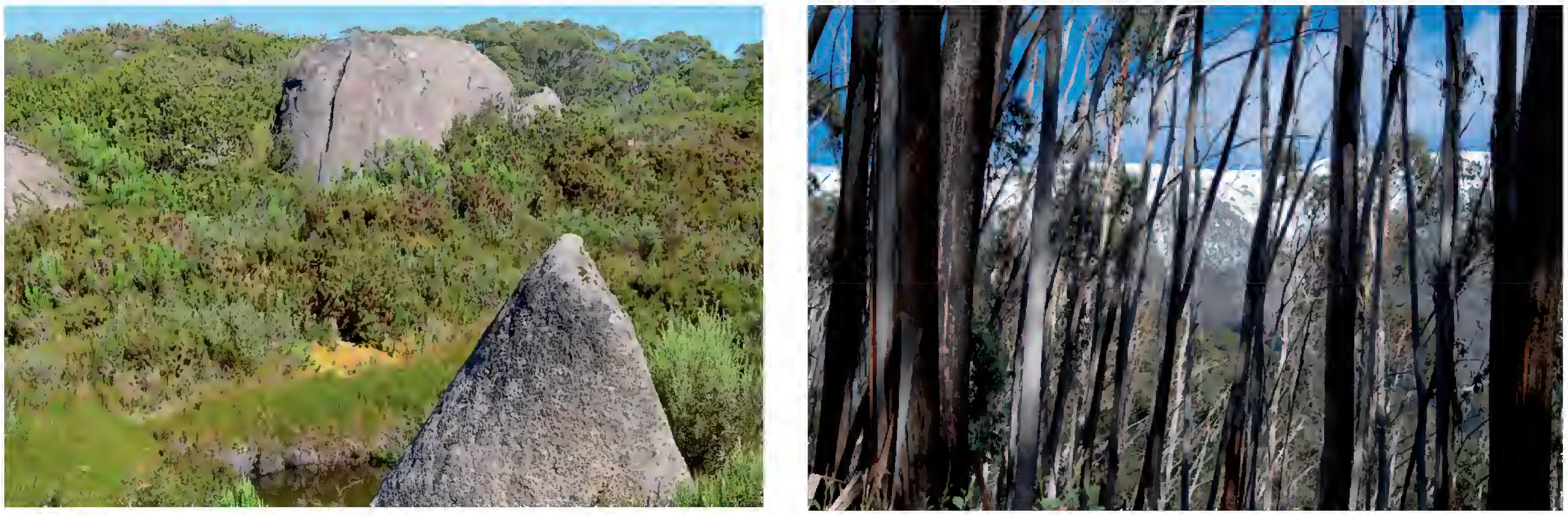
We present here a new classification and map of the Alps Network native vegetation types based on existing data interpreted by expert knowledge, along with a brief description of the source data and discussion on some of the major issues that needed to be resolved and potential applications.

Methods

The definitive approach to developing a new common vegetation system for a large cross-jurisdiction landscape such as the Alps Network would be to undertake a full re-assessment and analysis of the current native vegetation through quantitative on-ground surveys, using these survey plot data to generate a new statistically-based vegetation classification, and then using some form of remote sensing to map the vegetation classes. In the meantime, an alternative, practical approach is to gather available mapped vegetation data from jurisdictions and integrate the different vegetation types into a common classification that can be applied seamlessly across borders, while retaining the original classification units that can be referred to as needed. In addition, descriptive information from other pertinent vegetation surveys can be identified and used to help identify affinities across the vegetation classification systems.

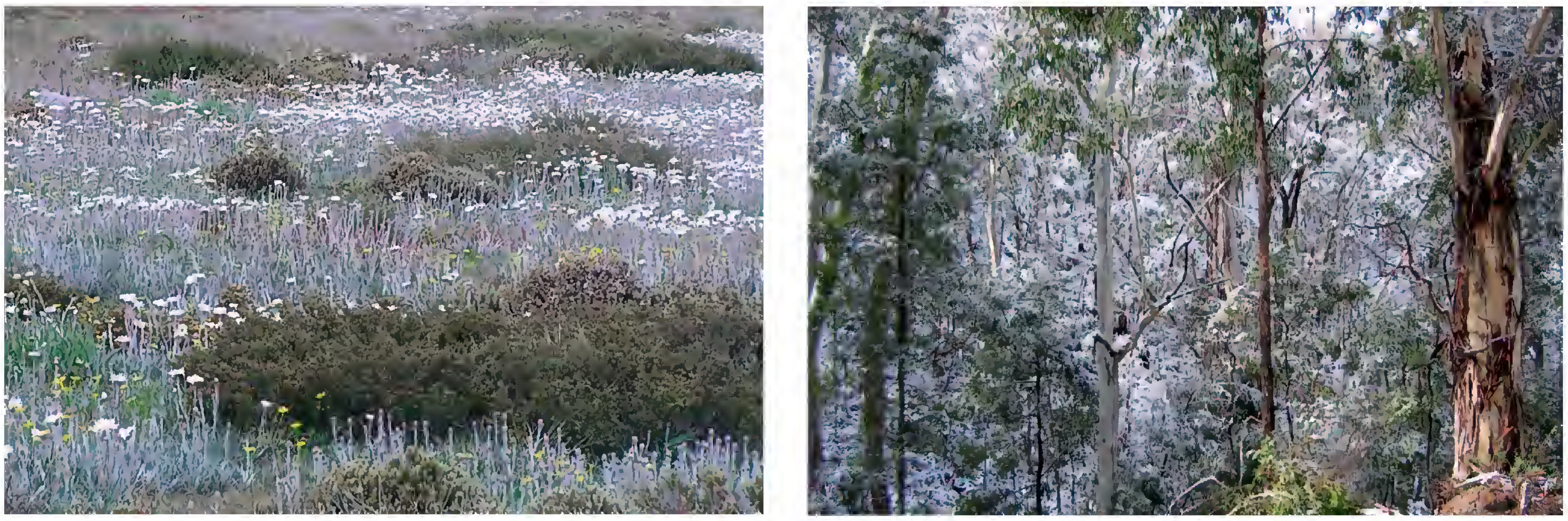
Table 1 National Parks within the Australian Alps National Parks Network.

Jurisdiction	**National Park**	**Area (ha)**
Victoria	Alpine National Park	660,550
	Snowy River National Park	98,100
	Avon Wilderness	39,650
	Mount Buffalo National Park	31,000
	Baw Baw National Park	13,300
New South Wales	Kosciuszko National Park	690,425
	Brindabella National Park	18,472
	Scabby Range Nature Reserve	4,982
	Bimberi Nature Reserve	10,886
Australian Capital Territory	Namadgi National Park	105,900
	Tidbinbilla Nature Reserve	5,450
Total area		**1,600,000**



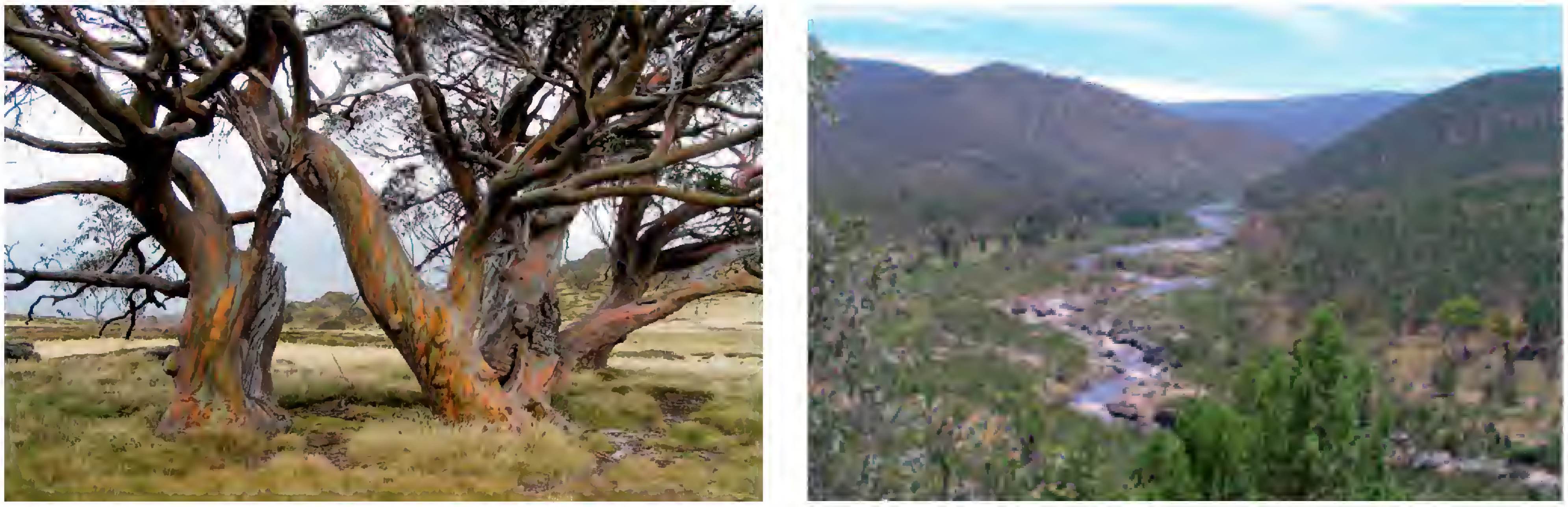
Alpine Bogs and Fens and Alpine Heathlands

Tall Wet Forests



Alpine Grasslands and Herbfields

Moist Montane Forest



Sub alpine Woodlands and Open forests

Rainshadow Woodlands and Open Forests

Fig. 1. Examples of major Alps-wide vegetation classes.

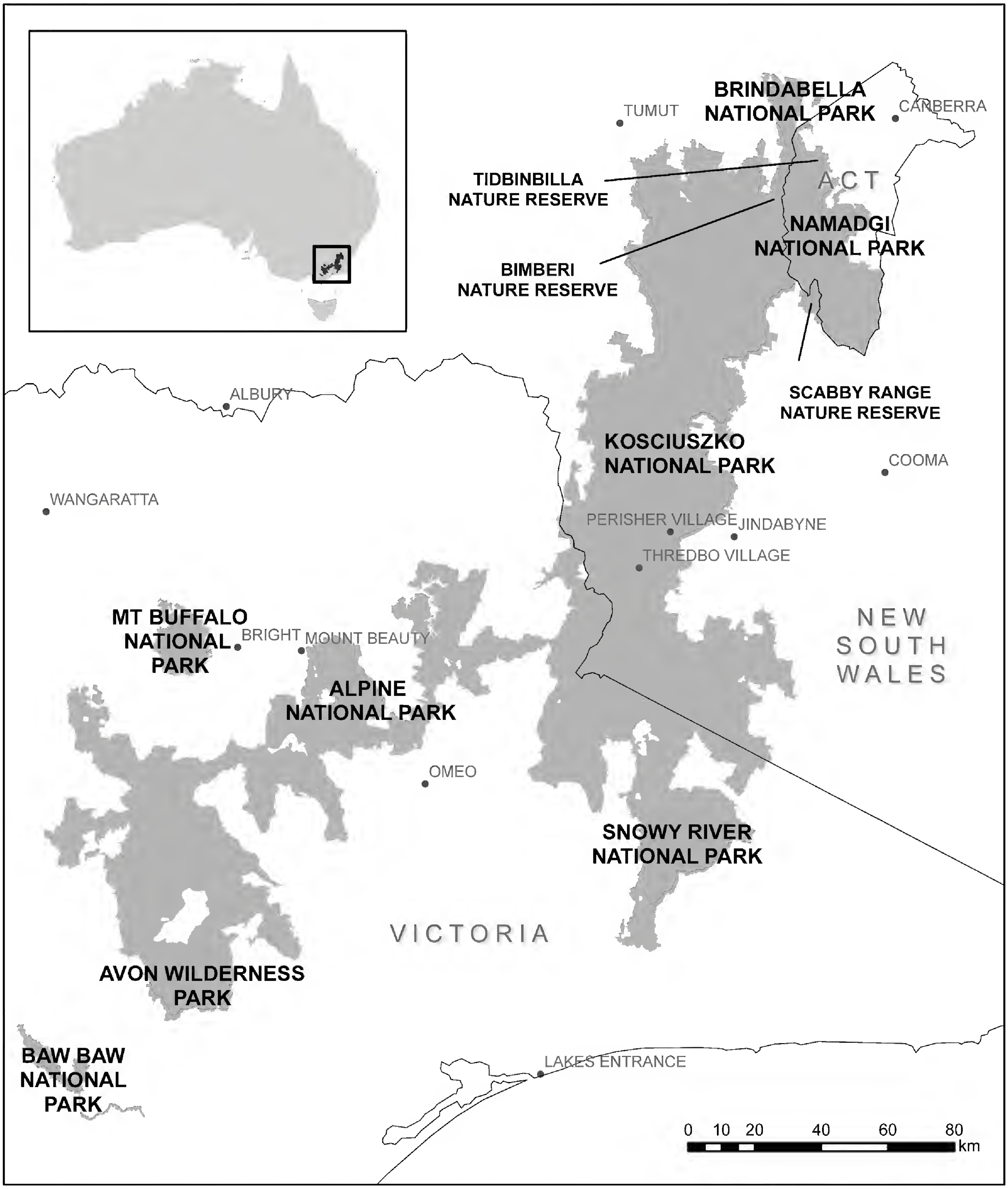


Fig. 2. Location of the Australian Alps National Parks Network.

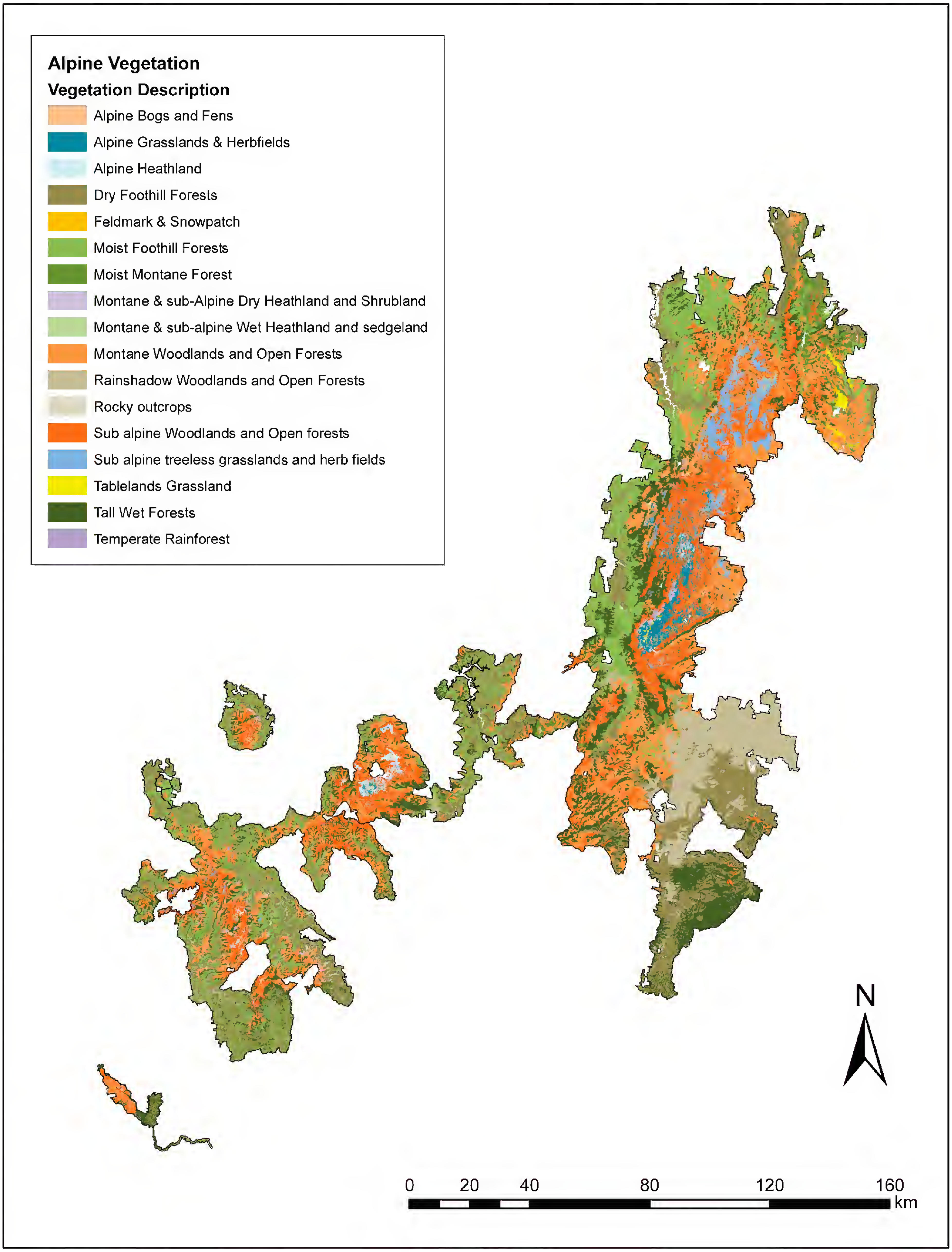

Alpine Vegetation
Vegetation Description
Alpine Bogs and Fens
Alpine Grasslands & Herbfields
Alpine Heathland
Dry Foothill Forests
Feldmark & Snowpatch
Moist Foothill Forests
Moist Montane Forest
Montane & sub-Alpine Dry Heathland and Shrubland
Montane & sub-alpine Wet Heathland and sedgeland
Montane Woodlands and Open Forests
Rainshadow Woodlands and Open Forests
Rocky outcrops
Sub alpine Woodlands and Open forests
Sub alpine treeless grasslands and herb fields
Tablelands Grassland
Tall Wet Forests
Temperate Rainforest
N
0
20
40
80
120
160
km

Fig. 3. Major vegetation types recognized by the new vegetation classification of the Alps Network.

While several studies describe the Alps Network vegetation to various degrees, the only two spatial datasets that were suitable for this study were those of Gellie (2005) for NSW and ACT and the Department of Sustainability and Environment (2015) for Victoria. The first step was to identify the distinctive and recognisable vegetation types that characterise the Australian Alps Network landscapes. The second step was to align and match the vegetation units of the NSW/ACT and Victorian classification systems. For Victoria, these are called Ecological Vegetation Classes and for NSW/ACT, Vegetation Groups.

To provide additional and updated information on vegetation types within each common class, vegetation community descriptions were also drawn from Armstrong *et al*. (2013) for NSW/ACT, along with those of McDougall & Walsh (2006) for treeless areas. A vegetation type of special concern is the Alpine Peatlands and Bog community, which is a nationally listed community (DEWHA 2009). This community type is incompletely mapped by both Gellie (2006) and by DSE's EVCs. Consequently, an additional Alpine Peatlands and Bogs layer was produced by combining more accurate Peatland mapping (Office of Environment and Heritage 2012; Arthur Rylah Institute 2008). In synthesising and integrating the available information about vegetation types, we drew upon our own knowledge of the region's ecology along with advice gained from consultations with three vegetation experts as detailed in the *Acknowledgements* section below.

The vegetation map was developed based on the new vegetation classification using a combination of the two base maps provided by Gellie (2005) and Office of Environment and Heritage (2012) for NSW/ACT and the Department of Environment, Land, Water and Planning (2014) for Victoria, along with the afore mentioned updated Alpine Peatlands and Bogs layer. The combined Alpine Vegetation map was created using ArcGIS desktop (ESRI 2014) and R software (R Core Team 2015). The new map was then clipped to the Australian Alps national park boundaries. All polygons classified as 'Alpine Bog and Fens' were merged into neighbouring polygons with the largest area or the longest shared border using the eliminate tool in the Generalization Toolbox of the Data Management Tools (ESRI 2014). The Alpine Peatlands and Bogs layer was then over-laid as the Alpine Bog and Fens classification.

Results

The aligned and matched EVCs and VGs, along with the new common Alps vegetation classes are described in Table 2. By way of summary, the classification matching exercise grouped 71 NSW/ACT vegetation groups (Gellie 2005) with 72 Victorian ecological vegetation classes (DSE 2015) to produce 17 common vegetation classes (see Figures 2 and 3). These 17 vegetation classes were then further grouped into five broad vegetation character classes (A-E below):

A. Lower to mid elevation forests and woodlands[1]: (1) Temperate Rainforest; (2) Moist Foothill Forests: (3) Dry Foothill Forests; (4) Rainshadow Woodlands and Open Forests;

B. Montane grasslands, forests and woodlands: (5) Tablelands Grassland: (6) Moist Montane Forest: (7) Tall Wet Forests; (8) Montane Woodlands and Open Forests;

C. Open Rocky outcrops: (9) Rocky outcrops;

D. Sub-alpine woodlands, open forest and treeless: (10) Sub alpine Woodlands and Open forests; (11) Sub alpine treeless grasslands and herb fields; (12) Montane & sub-alpine Wet Heathland and Sedgeland; (13) Montane & sub-Alpine Dry Heathland and Shrubland; and

E. Alpine treeless: (14) Alpine Bogs and Fens; (15) Alpine Heathland; (16) Feldmark & Snowpatch Herbfield; (17) Alpine Grasslands & Herbfields.

The vegetation information summarised in Table 2 and a detailed digital version of the vegetation map (Figure 3) are available to download from the Terra Nova Climate Change Information Climate Change Adaptation Information Portal at <https://terranova.org.au/repository/australian-alps-network-vegetation-classification>

A version of the new vegetation map is also available as part of a MCAS-S data pack that can be downloaded from <http://www.nerplandscapes.edu.au/data-packs - *Alps Icons & Threats Data Pack*>. The Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S) (Lesslie *et al*. 2008) is a decision support tool designed specifically for non-GIS experts to easily visualise and analyse spatial data when addressing natural resource management and planning problems.

Discussion

The development of the new vegetation classification and map was primarily limited by the availability of spatial vegetation data. These available spatial data were developed a decade ago and while there have been more recent vegetation and floristic studies in the bioregion the mapped data have not been updated to reflect recent findings and land cover changes. As noted in the methods section, where available, some more recent vegetation survey and descriptive work was incorporated into the new classification, however this information was not geographically comprehensive. At the time of our analyses, NSW was in the process of updating its state-wide biometric data, which could only be partly used, and is also incomplete in terms of coverage.

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[1] Lower to mid elevation refers to areas that extend from the lowest to the median elevation areas of the Australian Alps (i.e.100m up to around 1000m ASL), (see Table 2).

Table 2 Vegetation Units descriptions of the Australian Alps national parks.

MAPPED VEGETATION GROUPS & CLASSES				ALPS WIDE VEGETATION CLASSES		
NSW/ACT: VEGETATION GROUPS (Gellie 2005)		VICTORIA: ECOLOGICAL VEGETATION CLASS (EVC)		ALPS INTEGRATED VEGETATION CATEGORIES		
VEGETATION GROUPS	CODE[2]	COMPARABLE EVC CLASS IN GROUPING	EVC No	COMBINED ALPS VEGETATION CLASS	DESCRIPTION[3] AND TYPICAL SPECIES[4]	VEGETATION CHARACTER
Kosciuszko Western Escarpment Cool Temperate Rainforest	172	Cool Temperate Rainforest	31	**Temperate Rainforest**	Rainforests are closed forests not dominated by eucalypts. Cool temperate rainforest commonly contains *Atherosperma moschatum* & *Dicksonia antarctica* with *Nothafagus cunninghamii* in some cases in Victoria and has a strong floristic affinity with the Tall Wet Forests. Warm Temperate rainforest occurs in East Gippsland and the southern fall in Victoria, commonly containing *Acmena smithii, Acacia melanoxylon* & *Rapanea howittiana*. The Dry Rainforests of East Gippsland contain *R. howittiiana* along with *Pittosporum undulatum* & *Brachychiton populneaus*.	**Lower to mid elevation forests and woodlands**
		Warm Temperate Rainforest	32			
		Dry Rainforest	34			
Western Montane Acacia Fern-Herb Forest	82	Valley Grassy Forest	47	**Moist Foothill Forests**	Moist Foothill Forests are mixed species herb rich and shrubby forests of foothills and mid slopes occurring from the lower elevations around 100m generally up to 1000 m ASL, with some occurrences up to 1200m. The moister conditions (than that of dry foothill forest) are largely due to aspect and/or soil type. Generally, their elevation range is limited as they merge into the higher Montane Forest and Woodlands or Tall Wet Forests at around 900m to1000 m ASL. Commonly dominated by *Eucalyptus radiata* & *E. robertsonii* with occurrences of *E. dives, E. bridgesiana, E. cypellocarpa, E. dalrympleana, E. mannifera E. rubida* & *E. rossi* with *E. camphora* in wetter areas. *E. obliqua* and *E. fastigata* may occur in moist deep soils & *E. macrorrhyncha* where drier, particularly in the north. Mid storey species may include *Acacia melanoxylon* & *A. dealbata*. Includes riparian woodlands, scrubs & shrublands, which may merge into montane heathlands.	**Lower to mid elevation forests and woodlands**
Riparian Acacia Shrub-Grass-Herb Forest	53	Riverine Escarpment Scrub	82			
		Swampy Riparian Woodland	83			
		Riparian Shrubland	19			
Tableland Acacia-Herb-Grass Forest	104	Lowland Forest	16			
Eastern Dry Shrub-Herb-Grass Forest	81					
Northern Tablelands Acacia Herb/Grass Dry Forest	90					
Western Tablelands Herb-Grass Dry Forest	93					
South West Slopes Acacia Dry Herb-Grass Forest	94	Shrubby Foothill Forest/ Damp Forest Complex	315			
Montane Dry Shrub-Tussock Forest	106	Herb-rich Foothill Forest	23			

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[2] From Gellie (2005), not the NSW State Classification system.

[3] Elevation ranges for vegetation classes vary significantly with latitude and aspect, therefore elevation ranges stated are general indications only.

[4] Species and their composition vary with localities and between vegetation groups/EVC's in the combined Alps class. The typical species are a selection only, drawn from Gellie (2005), Department of Sustainability and Environment. (2015), Armstrong et al. (2013) and McDougall, K.L. & Walsh, N.G. (2007) and are not intended to be comprehensive.

Western Escarpment Dry Shrub Forest	70	Heathy Dry Forest/ Grassy Dry Forest	320	**Dry Foothill Forests**	Dry Foothill Forests are mixed species foothill and mid slope forests occurring from the lower elevations around 100m up to 1000 m ASL. They occur in drier situations than moist foothill forest due to aspect or soil type. Generally, their elevation range is limited as they merge into the higher Montane Forest and Woodlands or Tall Wet Forests at around 800-1000 m ASL. Commonly dominated by *Eucalyptus dives*, along with *E. mannifera*, *E. rubida* and *E. rossii*, the box species, *E. goniocalyx*, *E. nortonii*, *E. bridgesiana*, *E. polyanthemos* and *E. melliodora*, & stringybarks such as *E. macrorhyncha* and *E. dalrympleana* may mix in at higher elevations. *Daviesia latifolia*, *D.ulicfolia* & *Cassinia longifolia* are likely to be found in the understory.	**Lower to mid elevation forests and woodlands**
Tablelands Dry Shrub-Tussock Grass Forest	114	Dry Valley Forest	169			
Western Tableland Dry Shrub Forest	71	Grassy Dry Forest	22			
Western Tablelands Dry Herb-Grass Forest	108	Heathy Dry Forest	20			
Widespread Tablelands Dry Shrub-Tussock Grass Forest	109	Valley Heathy	127			
Tablelands Shrub-Tussock Grass Forest	75	Shrubby Foothill Forest	45			
Montane Dry Shrub-Tussock Grass Forest	79					
Tablelands Dry Shrub-Grass Forest	110	Clay Heathland	7			
South East Tablelands Dry Shrub-Tussock Grass Forest	115					
Western Slopes Grass-Herb Dry Forest	121	Valley Slopes Dry Forest	177			
Western Slopes Dry Shrub-Grass Forest	119					
South Eastern Tablelands Dry Shrub-Grass-Herb Forest	74					
Eastern Tableland Dry Shrub-Grass Forest	73					
SC-CT-ST Herb-Grass Forest on Limestone	198					
Western Montane Dry Fern-Grass Forest	103	Shrubby Dry Forest	21			
ACT Dry Shrub-Herb Forest	80					
Lower Snowy White Box Dry Shrub-Herb Woodland	78	Grassy Woodland	175	**Rainshadow Woodlands and Open Forests**	Rainshadow Woodlands and Open Forests are lower elevation dry woodlands and open forests occurring on steep dry slopes from 110m up to about 700 m ASL on poorly structured soils. They include the Snowy River Valley rainshadow woodlands. Generally dominated by *Eucalyptus albens*, *E. nortonii* & *E. goniocalyx*, with *E. dives*, *E. macrorhyncha*, *E. mannifera*, *E. blakelyi* & *E. polyanthemos* which may be present along with *Callitris glaucophylla*, *Brachychiton populneus*, *Exocarpus cuppressiformis*, *Acacia mearnsi* & *A. implexa*. Includes dry scrubs of *Acacia silvestris* & *Eriostemon trachyphyllus*.	
Western Slopes Herb-Grassy Woodland	116					
Lower Snowy Rain Shadow Woodland - Shrubland	41	Granitic Hills Woodland	72			
Lower Snowy Dry Shrub-Tussock Grass Forest	77					

Tableland Dry Heath Shrub-Herb-Grass Woodland	38	Foothill Box Ironbark Forest	24			
South Coast and Byadbo Acacia Scrubs	35	Blackthorn Scrub	27			
Tableland Moist Herb-Grassland	152			**Tablelands Grassland**	Tablelands Grassland is dominated *by Themeda australis & Poa sieberiana*. It occupies a small area in the alps, occurring in sub-alpine valleys in Namadgi National Park and is known to occur also in Victoria's eastern high country but is not mapped.	**Montane grasslands, forests and woodlands**
Tableland Tussock Grassland -Sedgeland	148					
Tableland and Escarpment Wet Layered Shrub Forest	58	Shrubby Damp Forest	316	**Moist Montane Forest**	Moist Montane Forest is a Tall mixed species forest, commonly occurring in higher moist situations ranging from 1000 m to 1500m ASL, but lower in Riparian forest areas, particularly in the south. It is generally positioned above the foothill forests and mixing at that elevation with the Tall Wet Forests and Montane Woodlands and Open Forests. Forest are generally dominated by *Eucalyptus dalrympleana & E. fastigata*, with occurrences of *E. robertsonii, E. dives, E. cypellocarpa, E. chapmaniana, E. viminalis, E.rubida & E. obliqua. E. pauciflora* may mix in at higher elevations. *Acacia dealbata, A.melanxylon, Daviesia ilicifolia, Exocarpus strictus & Persoonia chamaepitys* may occur in the understorey.	**Montane grasslands, forests and woodlands**
Montane Riparian Moist Shrub-Grass-Herb Forest	83	Riparian Forest/Creekline Grassy Woodland Mosaic	293			
Montane Riparian Moist Shrub/ Sedge/GrassForest	85	Riparian Forest/Swampy Riparian Woodland/ Riparian Shrubland/Riverine Escarpment Scrub Mosaic	84			
ACT Montane Dry Shrub Forest	105	Riparian Forest	18			
Central Tableland-ACT Montane Dry Shrub Forest	107	Montane Herb-rich Woodland	319			
Western Escarpment Shrub-Grass Forest	88					
Eastern Tablelands Acacia-Herb-Grass Forest	89					
Western Escarpment Moist Shrub-Herb-Grass Forest	87	Montane Damp Forest	38	**Tall Wet Forests**	Tall Wet Forests are the tallest forests in the Australian Alps typically dominated by *Eucalyptus delegatensis. E. delegatensis* forests occur throughout the alps high on the upper slopes between 900 and 1450 m ASL, mixing with *E. dalrympleana & E. pauciflora* at higher elevations. The understorey is commonly shrubby with species such as *Acacia obliquinervia, Daviesia nlicifolia & D.latifolia*, with a ground layer generally including herbs, tree ferns and grasses. *E. delegatensis* is very fire sensitive and an obligate seeder. Many stands have been burnt in the last 20 years, with large single age stands now in a scrubby regrowth stage and vulnerable to further fires until they mature. *E. regnans* forests are less common in the Australian alps, occurring on deep soils in moist gullies mainly on the southern fall between 300 m and 1100m ASL.	
Western Sub-alpine Moist Shrub Forest	86					
		Damp Forest	29			
		Wet Forest	30			
		Tableland Damp Forest	35			
		Montane Wet Forest	39			
		Shrubby Wet Forest	201			

Tableland Acacia Moist Herb Forest	95			Montane Woodlands and Open Forests	Montane Woodlands and Open Forests, including woodlands in riparian areas, occur widely between 800m and 1600m ASL on drier exposed slopes. Generally lower and more open than the moist tall montane forest at similar elevation, it is charactarised by the association of *Eucalyptus pauciflora* with *E. dalrympleana*, *E. rubida* & *E. dives* with *E. stellulata* & *E. camphora* in wetter and riparian areas. Understory may include *Acacia dealbata*, *A.obliquinervia*, *Cassinia aculeate*, *Hakea microcarpa*, *Epacris breviflora*, *Baeckea utilis*, *Daviesia ulicifolia*, *D.latifolia*, *D. mimosoides*, *Exocarpus strictus* & grasses, *Poa sieberiana* & *Themeda australis*.	
Western Montane Wet Heath-Herb Grass Woodland	124					
Western Montane Moist Shrub Forest	98					
		Montane Riparian Woodland	40			
		Treed Montane Riparian Woodland	40-61			
Brindabella Montane Dry Fern-Grass Forest	102	Montane Dry Woodland	36			
Tableland Tussock Grass/Herb Forest	96					
Montane Acacia-Dry Shrub-Herb-Grass Forest	97					
Tablelands Acacia Grass/Herb/ Dry Forest	101					
Central Tablelands Shrub-Grass Dry Forest	76					
ACT Montane Dry Shrub-Grass Forest	100	Montane Grassy Woodland	37			
Rock Outcrops	190	Alpine Crag Complex	1000	Rocky Outcrops	Rocky Outcrops are open rocky areas including scree slopes, with little or sparse vegetation, occurring at a range of elevations.	Open Rocky outcrops
		Rocky Outcrop Shrubland/ Rocky Outcrop Herbland Mosaic	73			
		Rocky Outcrop Shrubland	28			
Tableland Dry Herb-Grass Woodland	146	Sub-alpine damp heathy Woodland	978	Sub alpine Woodlands and Low Open Forests	Snow Gum Woodlands and low open forests are the highest treed areas in the Australian Alps and widespread, occurring generally between 1200m and up to 2000m ASL. They are dominated by *Eucalyptus pauciflora* or *E. niphophila*; small rocky exposed areas are dominated by other eucalypts, including *E. debeuzevillei*, *E. kybeanensis*, *E. glaucescens*, *E. forresterae* & *E. mitchelliana*. The understory ranges from grassy to scrubby. Species may include *Acacia obliquinervia*, *Oxylobium ellipticum*, *O.alpestre*, *Bossiaea foliosa*, *Kunzea muelleri*, *Olearia phlogopappa*, *Tasmannia xerophil*, *Leucopogon hookeri* & *Stellaria pungens* with several grasses including *Poa sieberiana P. hiemata* & *P. fawcettiae*.	Sub-alpine woodlands, open forest and treeless
Montane Dry Shrub-Herb-Grass Forest	99					
Scabby Range Dry Shrub Woodland	37					
Sub-alpine Dry Shrub-Herb-Grass Woodland	127					
Sub-alpine Dry Shrub-Herb Woodland	128					

Sub-alpine Shrub-Grass Woodland	130	Sub-alpine Woodland	43			**Sub-alpine woodlands, open forest and treeless**
		Sub-alpine wet heathy woodland	977			
Tablelands Moist Sedge-Herb-Grassland	147			**Sub alpine treeless grasslands and herb fields**	The Sub alpine treeless grasslands and herb fields commonly occur on the treeless high plains and frost hollows of the sub alpine area generally between 1200m and 1500 m ASL where snow persists for long periods over poorly drained soils. Grasses dominate with *Poa sieberiana P. labillardieri, P. costiniana & P. fawcettiae* occurring. A diverse range of other species occur including shrubs such as *Grevillia australis, Baeckea gunniana & Hovea montana*, the herbs *Scleranthus biflorus, Plantago antarctica, Ranunculus granticola & Craspedia spp.*, and the sedge *Carex gaudichaudiana.*	
Sub-alpine Grassland	131	subalpine grasslands	206			
Sub-alpine Dry Herb-Grassland	132					
		Sub-alpine Treeless Mosaic: Early mapping unit. Subject to recent mapping, may now include: 156, 171, 202, 206, 41, 42, 170, 210, 239, 288, 913,905, 1001, 1002, 1003, 1004, 1011,1012,1013, 1014	44			
Montane Wet Heath-Herb Grassland	125	Sub-alpine Wet Heathland/ Sub-alpine Grassland Mosaic	317	**Montane & sub-Alpine Wet Heathland and Sedgeland**	The Montane & sub-Alpine Wet Heathland and Sedgeland occur in treeless areas generally between 1000m and 1200m ASL, where soils are permanently wet, often along soaks and drainage lines. Sedges commonly include sedges *Carex gaudichaudiana, Juncus brevibracteus & J.falcatus*, shrubs may include *Epacris breviflora, Leptospermum myrtifolium, Baeckea utilis, & Hakea microcarpa*, with the herbs, *Neopaxia australasica* & several *Ranunculus spp.* and grass *Poa labillardieri.* This Wet Heathland does not include the Sphagnum spp. peat forming Alpine Bogs and Fens, which are listed below.	
Montane Wet Sedge land	126	Montane Swamp	318			
		Montane Riparian thicket	41			
		Montane Wet Heathland	184			
		Sub Alpine Damp Heathland	204			
Montane/Sub-alpine wet heath/ bog	123	Sub-alpine Riparian Shrubland	208			
Montane - Sub-Alpine Dry Rocky Shrubland	36	Montane Rocky Shrubland	192	**Montane & sub-Alpine Dry Heathland and Shrubland**	Montane & sub-Alpine Dry Heathland and Shrubland occurs generally between 1100m and 1500m ASL in a harsh environment often on exposed rocky areas on poor soils amongst stunted Snow Gums. Shrub species may include *Bossiaea riparia, B.foliosa, Hakea microcarpa, Oxylobium ellipticum Asterolasia trymalioides, Leptospernum micromyrtus, Podolobium alpestre, Kunzea muelleri & K. ericoides*, with grasses *Poa fawcettiae, P. tenera* & other Poa spp.	
		Sub-alpine Shrubland	42			
		Sub-alpine Dry Shrubland	1003			

"Alpine Bogs" Layer (Australian Alps composite bogs dataset) from OEH Technical Report: Peat-forming bogs and fens of the Snowy Mountains of NSW		"Alpine Bogs" Layer (Australian Alps composite bogs dataset). In Vic contains 288, 210, 1011, 171, 211 and other peatlands.		**Alpine Bogs and Fens**	Alpine Sphagnum Bogs and associated Fens occur in waterlogged and permanently wet treeless areas, such as along streams, drainage lines, valley edges and valley floors generally between 1200m to 1800m m ASL. They differ from Wet Heathland and Sedgeland in that they contain Sphagnum spp. (which is typically underlain by peat), the most common of which is *Sphagnum cristatum*, along with a diversity of sedges, herbs and shrubs. Species commonly include *Empodisma minus, Epacris glacialis, E. paludosa, Baeckea gunniana, B. utilis, Pratia surrepens & Richea continentis*. Fens adjoin the bog and are devoid of woody vegetation, commonly dominated by sedges such as *Carex gaudichaudiana*. The Alpine Sphagnum Bogs and associated Fens vegetation community is listed as endangered under the EPBC Act. (Department of the Environment, Water, Heritage and the Arts. 2009).	**Alpine Treeless**
Sub-alpine Wet Herb-Grassland-Bog	133	Sub-alpine Wet Heathland	210			
		Alpine Fen	171			
		Alpine Valley Peatland Raised Bog	288-61			
		Alpine Valley Peatland Valley Bog	288-62			
		Alpine peaty Heathland	1011			**Alpine Treeless**
		Sub-alpine Wet Heathland/ Alpine Valley Peatland Mosaic	211			
Alpine Rocky Low Open Heathland	207			**Alpine Heathland**	Alpine Heathland is a low open heathland occurring typically at high elevations from 1400m to over 2000m ASL. It is found high on slopes and rocky exposed areas on shallow soils. Shrubs may include *Podocarpus lawrencii, Prostanthera cuneata, Grevillia australis, Leucopogon spp. Hovea montana & Oxylobium ellipticum* with inter shrub spaces containing the herbs *Craspedia spp. & Celmisia spp.* and grasses *Poa fawcettiae & P. hiemata.*	
		Alpine Coniferous shrubland	156			
		Alpine Grassy Heathland	1004			
		Alpine Dwarf Heathland	170			
		Alpine Rocky Outcrop Heathland	1013			
		Alpine Rocky Outcrop Heathland/Alpine Dwarf Heathland Mosaic	1105			
		Alpine Grassy Heathland/ Alpine Grassland Mosaic	1005			

		Snow Patch herbland	202	**Feldmark & Snowpatch Herbfields**	Feldmark & Snowpatch Herbfields are bare low open alpine herbfields on barely developed soils at very high elevations, from 1600m to above 2000m ASL. Feldmark herbfields occur on exposed windswept ridges and summits and commonly include *Epacris petrophila, E. gunnii, Colobanthus pulvinatus, Ewartia nubigena, Chionohebe densifolia & Ranunculus acrophilus.* Snowpatch herbfields occur on the outwash of accumulations of late thawing snow which may persist into summer, truncating the growing season. Snowpatch species commonly include *Coprosma niphophila, Colobanthus nivicola, Neopaxia australasica, Oreobolus pumilio & various Ranunculus spp.* Grasses such as *Poa fawcettiae & Agrostis muelleriana* may occur in both.	**Alpine Treeless**
Snowpatch Alpine Feldmark	205	Snowpatch Grassland	1012			
		Alpine Creekline herbland	239			
Exposed Feldmark	204					
		Late -lying Snowpatch Herbland	1014			
Alpine Tall Herbfield	129			**Alpine Grasslands & Herbfields**	Alpine Grasslands & Herbfields occur from 1500m to the highest peaks above 2000m ASL where snow cover is more prolonged. They range from extensive thick grassy swards on the high treeless plains to the grassy herbfields of the high peaks and ridges. Shrubs may include *Grevillea australis, Pimelia axiflora, P. alpina, Pentachondra pumila, Olearia Phlogopappa, Epacris glacialis, Acena spp. & Oreobolus pumilio*. Of the herbs, *Celmisia spp., Craspedia spp., Aciphylla glacialis, Plantago muelleri & Caltha introloba* may be present. Grasses include *Poa fawcettiae P. constiniana, P. saxicola & Rytidosperma nivicolum* along with the sedge *Carex gaudichaudiana.*	
Short Alpine Herbfield	206	Alpine Short herbland	905			
		Alpine Grassland	1001			
		Alpine Damp Grassland	1002			
		Alpine Pond Herbland	913			

The mapped vegetation classes varied in the accuracy of their mapping, and of particular concern were the treeless areas (K. McDougall, personal communication, 2014; A. Tolsma, personal communication, 2014) for which the more recent Alpine Peatlands and Bogs mapping allowed a significant improvement. Despite the limitations and inconsistencies of data, the new vegetation classification and map is considered by the authors and experts who were consulted to be of sufficient accuracy for broad scale park planning and management purposes. Furthermore, being a digital, GIS-based information product, the new vegetation classification and map is readily refined and updated in response to new information from multiple sources including field survey data and remotely sensed data.

We therefore encourage the Australian Alps Co-operative management program to further refine this new vegetation information system by updating mapping of selected areas and incorporating contemporary ecological studies. The priority for further work should be based on the most sensitive and complex vegetation types and in particular the Sub-alpine and Alpine Treeless Areas, the Moist Montane Forests and their relationship with Montane Woodlands and Open forest, and Tall Wet Forests and their relationship with Cool Temperate Rainforest.

Providing information about the composition and structure of major vegetation classes in a common form across the multi-jurisdictional landscape provides fundamental information for protected area managers and practitioners working within the Australian Alps Network co-operative management framework. Mapped common vegetation classes can function as spatial planning units that serve a range of purposes including: locating representative monitoring plots; extrapolating management prescriptions; identification of nature-based tourist activities; establishing baselines for tracking ecosystem-level responses to climate change and fire regimes; and as inputs to models of wildlife habitat and species distributions.

Conclusion

In geographically extensive multi-jurisdictional protected area landscapes, a common vegetation mapping system is an essential information layer for systematic conservation planning and management. As we have shown here, this can be developed at a low cost utilising existing mapped data and integrating existing vegetation classifications by aligning and matching classes across the jurisdictions into a common system. This approach retains the connections to wider National and State or Territory corporate systems while generating a classification that recognised here both the common and distinctive vegetation character of the diverse landscapes that comprise the Alps Network.

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Should Hunter Valley Weeping Myall Woodland in the Sydney Basin Bioregion be listed as a Threatened Ecological Community?

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***Abstract*:** In New South Wales, the *Threatened Species Conservation Act 1995* makes provision for the listing of Threatened Ecological Communities (assemblages of species occupying a particular area) as a means to conserving the variety of ecosystems present in the State. Hunter Valley Weeping Myall Woodland is listed as an Endangered Ecological Community under the New South Wales *Threatened Species Conservation (TSC) Act 1995* and as a Critically Endangered Ecological Community under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*.

The provenance of populations of Weeping Myall (*Acacia pendula*, family Fabaceae) in the Hunter Valley has recently been questioned. In this paper we consider the implications of its hypothesized European introduction for listing Hunter Valley Weeping Myall Woodland under the *TSC* and *EPBS Acts*. The recognition of any community is contingent on the identification of both a particular assemblage of species and the critical environmental factors that determine their co-occurrence (the area the community occupies in environmental space). *Acacia pendula* is one of a range of semi-arid species which are primarily distributed west of the Great Dividing Range but also occur on Permian sediments in areas receiving the lowest rainfall of the Hunter Valley floor. On this basis we argue there is sufficient evidence to support the listing of Hunter Valley Weeping Myall Woodland under both *Acts*.

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Introduction

Weeping Myall (*Acacia pendula*, family Fabaceae) is widely distributed throughout the western slopes and plains of New South Wales (NSW) and parts of Queensland and Victoria. The eastern limit of its distribution in NSW is marked by an outlying population between the locations of Broke, Singleton, Muswellbrook and Sandy Hollow in the upper Hunter Valley. Both the provenance and taxonomic affinities of the Hunter population have been the subject of debate. Most recently, Bell and Driscoll (2014) made a persuasive argument that the Hunter population was not present at the time of European settlement but was introduced at some time in the second half of the twentieth century. As a consequence, they suggested that the status of *Acacia pendula* under the NSW Threatened Species Conservation Act (1995) (Endangered Population and Endangered Ecological Community) and Commonwealth *Environment Protection and Biodiversity Conservation Act (1999)* (Critically Endangered Ecological Community) should be reviewed.

Bell and Driscoll's (2014) case was based on several lines of evidence. First, they noted that while the journals of early Australian explorers made copious references to the presence of *Acacia pendula* in the western parts of its current range there were no mentions of its presence in the Hunter Valley. They argued that since the species is conspicuous and the exploration of the Hunter was no less thorough than elsewhere then it must have been absent at the time of colonisation. Second, no reliable herbarium records of *Acacia pendula* exist from the Hunter Valley prior to 1951, although collections have proliferated during the second half of the 20th century. Bell and Driscoll (2014) argued that such a pattern is again unlikely, given the extensive botanical exploration of the Hunter Valley, unless the species was introduced to the Hunter relatively recently.

Finally, with the exception of the Hunter Valley, *Acacia pendula* is restricted to the semi-arid slopes and plains west of the divide. Bell and Driscoll (2014) demonstrated that in addition to being remote from its western neighbours, the Hunter population occupies a different environmental niche characterised by higher rainfall (600 – 800 mm vs 300 – 600mm), higher elevation (200 – 299 m vs 100 – 199 m) and different soils (Sodosols/Kurosols vs Vertosols/Chromosols). The fact that this broader niche has only been realised in the Hunter Valley suggested, to Bell and Driscoll (2014), that the species must have been specifically introduced there.

Upgrade, defer, delist?

The publication of Bell and Driscoll's (2014) paper coincided with the exhibition of a preliminary determination made by the NSW Scientific Committee to list Hunter Valley Weeping Myall Woodland in the Sydney Basin Bioregion as a Critically Endangered Community under the *TSC Act 1995*. The determination upgrades the conservation status of the community from Endangered to a level equivalent to its listing under the Commonwealth *EPSB Act* (1999). Doubts over the provenance of *Acacia pendula* in the Hunter Valley raise the question of whether either listing is appropriate. Bell and Driscoll (2014) suggested that the conservation status and management of the community should be reviewed and that genetic studies are urgently required to resolve the matter of the provenance and genetic integrity of *Acacia pendula*. They further speculated that the species may even pose a threat to the conservation of floristic diversity through the competitive exclusion of understorey species.

A more general concern is whether there is quantitative support for the recognition of Hunter Valley Weeping Myall Woodland as a distinct assemblage of species. Limited sampling of the community has precluded a quantitative appraisal of its distinctiveness relative to other vegetation of the Hunter Valley (Peake 2006, Somerville 2009a&b, Sivertsen *et al*. 2011). Examining this question, Bell (2012) subsequently demonstrated (via ordination) a divergence of samples of the Hunter Myall Woodland assemblage from other grassy woodlands in the central and upper Hunter Valley (irrespective of the presence of *Acacia pendula* itself). However, he suggested that this divergence was a reflection of the depauperate understory characteristic of dense populations of *Acacia pendula*. In general, competent, experienced botanists remain unconvinced the Hunter Valley Myall Woodland constitutes an assemblage of species distinct from others occurring in the upper Hunter Valley.

Is there an ecological basis for CEC listing?

Whether populations of *Acacia pendula* were present, absent, incipient or dormant in the Hunter Valley at the time European settlement is not strictly relevant to the status of the Hunter Valley Weeping Myall Woodland. While its presence may be accepted as a *de facto* diagnostic feature of the community (Umwelt 2006), the *TSC Act 1995* defines a community as "an assemblage of species occupying a particular area" and the absence of any species in a particular sample is explicitly anticipated by the Determination. Nevertheless, the long history of disturbance in the Hunter Valley, combined with a paucity of systematic, quantitative survey data, increases the risk that biogeographic patterns are confounded with anthropogenic artefacts. What, then, is the ecological basis for recognising the community?

The assemblage of species listed in the Preliminary Determination to list Hunter Valley Myall Woodlands as a Critically Endangered Community includes a number of species that are primarily distributed on the western slopes and plains and reach their eastern distributional limit in the upper Hunter Valley. These species show a similar distributional pattern to *Acacia pendula* and hence, occupy a different environmental niche to their more western populations. They are generally restricted to the areas of weathered Permian Sedimentary bedrock or Quaternary Alluvium but vary in the range of elevation and rainfall over which they are distributed. Species with relatively broad distributions (*Acacia salicina, Notelaea microcarpa var. microcarpa, Maireana microphylla, Minuria leptophylla, Geijera parviflora* and *Ptilotus nobilis* subsp *semilanatus*) are characteristic of a number of community types occurring in the upper Hunter Valley (Peake 2006, Somerville 2009a&b, Sivertsen *et al.* 2011). The distribution of a second group of species (*Calocephalus citreus, Acacia melvillei, Enteropogon acicularis, Eragrostis alveiformis*) is more restricted. Records of these species are distributed over a similar area to those of *Acacia pendula* between Broke, Singleton, Muswellbrook and Sandy Hollow (Atlas of Living Australia, Accessed 13th August 2015). The distribution of *Enchylaena tomentosa, Lysiana exocarpi* subsp. *tenuis,* and *Chenopodium glaucum* follows a similar pattern although these species are also distributed on (or, in the case of *C. glaucum*, otherwise restricted to) the coast. Bell (2012) identified a number of these species as either statistically diagnostic or compositionally characteristic of a set of five plots sampling putative Hunter Weeping Myall Woodlands. Conversely, a subset of these species were either absent from, or rare in other communities described by Peake (2006), Somerville (2009a&b) and Sivertsen *et al.* (2011),

The patterns in the distribution of plant species described above are strongly correlated with annual rainfall, geology and topography. The eastern limits of species with western affinities are approximately demarcated by the 700 mm isohyet to the east of which rainfall rises steeply reaching 1000 mm over the 60 km between Singleton and Maitland. Rainfall also increases with elevation to both the north and south, rising to approximately 1000 mm on the Liverpool Range. The 700 mm isohyet defines the eastern limit of a rain-shadow extending some 200 km west up the Goulburn River Valley and beyond the Divide to Dunedoo. While rainfall is relatively invariant (625-675 mm) along this corridor the distribution of species characteristic of Hunter Valley Myall Woodlands is truncated to the west of Sandy Hollow at a location which corresponds approximately to the outcropping of Triassic Narrabeen sandstones in the Goulburn River Valley.

While the intersection of the western limit of the Hunter Permian sediments and the Goulburn River Valley rain shadow clearly constitutes a unique environmental niche, the Hunter Valley Myall Woodland is one of several candidate assemblages associated with this area. The closest alternative to Hunter Valley Myall Woodland, in terms of species composition and habitat, is Peake's (2006) Central Hunter Box-Ironbark Woodland (Map Unit 10). Peake (2006) identified six variants of this community occurring in habitats ranging from valleys to gently undulating hills, slopes and rocky knolls. In contrast, he described Hunter Valley Myall Woodlands as occurring on heavy clay soils associated with flood washouts. Sivertsen *et al.*'s (2011) Narrow-leaved Ironbark/ Grey Box grassy woodland of the central and upper Hunter (Map Unit 173) is an alternative interpretation of the same community, but is more extensively distributed at higher elevations in the upper Hunter Valley up to the 725 mm isohyet to the north, and in areas receiving up to 900 mm northeast of Ravensworth. Compared with either of the communities described above, the current distribution of *Acacia pendula*, whatever its origin, is a better approximation of the distribution of an interesting assemblage of semi-arid species in areas of lower rainfall along the valley floor.

One final factor for consideration concerns the location of the Hunter Valley Myall Woodlands with respect to the potential dispersal path of species moving from west to east. Beadle (1981) characterised the Goulburn River valley as one of the few places where the Great Diving Range posed a minimal barrier to the dispersal of species from west to east. The Goulburn River potentially facilitated this process and, as such, the junction of the Goulburn and Hunter Rivers with their associated floodplains potentially represents the first suitable habitat for species adapted to the heavier soils and floodplains west of the range. From this perspective, the remoteness of the Hunter *Acacia pendula* population from its western neighbours is potentially a function of discontinuities in the edaphic and climatic niche it is able to exploit.

Conclusion

While the origins of *Acacia pendula* in the Hunter Valley may be uncertain, its current distribution is indicative of important underlying patterns in the distribution of multiple species in relation to soil and climatic gradients. These patterns have been undoubtedly muted by disturbance over the past two centuries, just as the abundance of *Acacia pendula* (if it was present at the time of European settlement) has likely changed. Nevertheless, the co-occurrence of these multiple species in various combinations establishes the existence of an assemblage consistent with the definition of an ecological community under both the NSW *Threatened Species Act* 1995 and the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999. Whether the protection of Hunter Valley Myall Woodlands is conceived as conserving the last vestiges of Pleistocene Age semi-arid flora of the Hunter Valley (Tame 1992) or the eastern outpost of the contemporary semi-arid flora (Beadle 1981), the community is potentially the repository of important components of the genetic and ecological variability of its component species. Given the evidence supporting the distinctiveness of the assemblage and consistency with definitions of an ecological community, its restricted distribution and threats (Peake 2006, Department of Environment 2014, earlier *TSC Act* listing), continued protection of Hunter Valley Myall Woodlands as a Critically Endangered Community appears to be warranted.

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